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# Feasibility Study Report
# United Heckathorn Site
# Richmond, California

January 11, 1991
1530.02

Prepared for

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**FEASIBILITY STUDY REPORT**
**UNITED HECKATHORN SITE**
**RICHMOND, CALIFORNIA**

## 1.0 INTRODUCTION

### 1.1 Purpose and Organization of Report

Levine•Fricke has prepared this Feasibility Study (FS) Report on behalf of Levin Richmond Terminal Corporation (LRTC), the current occupant of the United Heckathorn Site (the Site). The Site is owned by LRTC's parent company, Levin Enterprises, Inc. (formerly Levin Metals Corporation). The Site is located at 402 Wright Avenue, in Richmond, California (see Figure 1-1).

The FS Report uses the information acquired during the remedial investigation (RI) to develop remedial action objectives and a range of possible alternatives to protect human health and the environment. In accordance with the Superfund Amendments and Reauthorization Act of 1986 (SARA), these remedial action objectives and alternatives are based on a public health evaluation (PHE) and a review of the Applicable or Relevant and Appropriate Requirements (ARARs) for the Site.

This FS report is organized into the following four sections:

Section 1.0 provides background information about the Site, reviews environmental sampling results from Levine•Fricke's RI Report (1990a), and summarizes the potential health and environmental risks associated with exposure to these chemicals.

Section 2.0 describes the FS process in greater detail, identifies ARARs, and develops remedial action objectives for the Site.

Section 3.0 identifies general response actions and associated remedial technologies, based on the RI data and conceptual engineering evaluations. These remedial technologies are screened for technical implementability. One or more specific process options are identified for those remedial technologies that are considered to be technically implementable. These process options are then screened using the general criteria of effectiveness, implementability, and order of magnitude costs.

Section 4.0 develops a range of possible remedial alternatives for the Site by combining various process options that were retained through the screening steps described in Section 3.0.

The alternatives developed in this manner are then evaluated in detail according to U.S. Environmental Protection Agency (EPA) and State of California criteria.

## 1.2 Background Information

In March 1982, the California Department of Health Services (DHS) included the Site on its list of State Superfund sites because of pesticide contamination resulting from the industrial activities of previous site occupants. On March 14, 1990, the EPA listed the Site on its National Priorities List (NPL) of Federal Superfund sites. During the summer of 1990, the EPA began oversight of the RI/FS and cleanup as the lead government agency for this federal Superfund site.

This FS Report for the Site is based on and is consistent with:

1. The National Oil and Hazardous Substance Contingency Plan (NCP), 40 C.F.R. Part 300 (1990) and the Superfund Amendments and Reauthorization Act of 1986 (SARA) 42 U.S.C. Sections 9601 et seq.

2. The requirements of California Health and Safety Code Section 25356.1 for preparation of a Remedial Action Plan (RAP) under the California Hazardous Substances Account Act.

3. Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, Interim Final -- OSWER Directive 9355.3-01 (EPA RI/FS Guidance Document) (EPA, 1988a).

### 1.2.1 SITE DESCRIPTION

For the purposes of the remedial investigation and this feasibility study (RI/FS), the Site has been divided into the following areas, as shown in Figure 1-2:

1. Upland Area: This part of the Site is relatively level, with elevations ranging from approximately 7 to 11 feet above mean sea level (MSL). The northern part of the Upland Area includes the former operations area of the United Heckathorn Company and other former industrial tenants. As an interim remedial measure, LRTC has covered this part of the Site with approximately 1.5 feet of gravel.

2. Eastern Embankment of the Lauritzen Canal: This part of the Site comprises the intertidal zone where the Upland Area changes slope to form the shoreline of the Lauritzen Canal. The eastern embankment area consists primarily of rubble and sandy gravel fill overlying Bay Mud. It has a slope of approximately 2:1 (horizontal to vertical) or steeper. Most of the embankment is covered by a pile-supported wharf used to load and unload cargo vessels. Steel and timber retaining walls have been installed along much of the landward side of the wharf as an interim measure to reduce erosion of the embankment and Upland Area.

3. Offshore Sediments in the Lauritzen Canal: The Lauritzen Canal is approximately 1,800 feet long and ranges from approximately 20 to 40 feet deep. The north end of the Lauritzen Canal is about 150 feet south of Cutting Boulevard, and the south end of this waterway is bordered by the Santa Fe Channel.

### 1.2.2 SITE HISTORY

#### 1.2.2.1 Site Use Activities

The first industrial use of the Site and surrounding area is believed to have occurred during World War II. At that time, a ship building operation occupied extensive land in the area that included the Site. Immediately following the war, the shipyard and most supporting structures were demolished.

Parr Richmond Terminal Company, Parr Terminal Company, and/or Parr Industrial Corporation owned and/or leased the Site from the mid-to-late 1940s until 1981. From approximately 1947 to 1966, the Site was used by several operators, including Universal Pigment and Chemical Company, R.J. Prentice Company, Heckathorn and Company, United Heckathorn, United Chemetrics, and Chemwest Incorporated, to manufacture and package various chemical products. For purposes of this FS Report, these companies are collectively referred to as the "United Heckathorn Company" or "United Heckathorn facility."

DDT and other pesticides were the primary chemicals processed at the United Heckathorn facility. These processing activities included pesticide mixing, blending, grinding, and packaging. Various solvents, including xylenes, were used to dissolve pesticides into liquid formulations. These solvents were stored in several aboveground tanks and drums. Table 1-1 lists the chemicals that were reportedly used at the Site, based on an inspection by the Regional Water Quality Control Board (RWQCB) on June 15, 1960, and on more recent information provided by former United Heckathorn employees.

United Heckathorn employees are reported to have routinely washed out equipment containing pesticide residues and washed pesticide dust out of the grinding facilities. The wash water was permitted either to run through drains that discharged to the Lauritzen Canal or to seep into the ground adjacent to the former facility. During the later years of United Heckathorn's operation (approximately 1960-65), some attempt was made to settle pesticides and other solids out of the wash water using settling tanks. However, California Department of Fish and Game (CDFG) staff observed overflow and leakage from those tanks which were located directly next to the Lauritzen Canal. In addition, solids removed from the tanks were dried (for reuse) out of doors in the open air. There is also evidence of accidental spills, leaks, and releases during the processing of liquid and dry pesticide formulations, which occurred both inside and outside the United Heckathorn building.

The United Heckathorn facility operations were concentrated over the northern half of the Site, in and around the buildings identified as Buildings 1 through 4 (see Figure 1-2). Pesticide formulating activities at the Site are believed to have ended in approximately 1966. Between 1966 and 1970, the United Heckathorn facility buildings were demolished and cleared from the Site. In the 1970s, the Site appears to have been used primarily for bulk material storage.

Unaware of the existing contamination at the Site, Levin Metals Corporation purchased the property from Parr-Richmond Terminal Company in 1981. LRTC has been operating a bulk shipping facility on the southern portion of the Site from 1981 to the present time. Bulk materials temporarily stored by LRTC include coal, coke, bauxite, and other items. LRTC has not handled any pesticides during its use of the Site. Current structures on the Site include a warehouse, maintenance building, LRTC office, railroad hopper building, pile-supported railroad dock, and railroad tracks.

#### 1.2.2.2 Previous Site Investigations

After pesticide processing activities ended at the Site in 1966, no further regulatory agency investigations were performed at the Site until August 1980. At that time, the DHS Abandoned Site Project staff inspected the Site and collected several soil samples in the northern area where pesticides previously had been stored and formulated. These samples indicated the presence of several pesticides and metals.

In October 1980, DHS advised the current property owner, Parr Richmond Terminal Company, of its sampling results and possible cleanup requirements. LRTC learned of this problem in 1982, after purchasing the property, when informed by government officials. In March 1982, DHS included the Site on its list of State Superfund sites. In response to an RWQCB letter dated November 22, 1982, LRTC retained Harding Lawson Associates (HLA) of Novato, California, to characterize contamination by the previous site occupants and to evaluate possible remedial alternatives for the Site.

HLA implemented its field investigation in three phases between 1983 and 1986. The investigation included drilling soil borings, installing monitoring wells, and collecting offshore sediments from the Lauritzen Canal. HLA also conducted air monitoring, biological and chemical analyses of canal organisms, and hydraulic testing of ground water at the Site. The findings of this investigation are presented in HLA's report entitled "Revised Draft Site Characterization and Remedial Action Plan, Former United Heckathorn Site," dated November 6, 1986 (HLA, 1986b).

Although these previous investigations provided much useful information, the DHS, RWQCB, and CDFG indicated that site characterization activities had not adequately characterized the Site. Specifically, these agencies requested additional chemical analysis of soil samples for solvents, and additional chemical analyses of offshore sediment samples from the Lauritzen Canal and Santa Fe Channel. Therefore, the field investigation described in Levine•Fricke's RI Report (1990a) was implemented to more thoroughly characterize the Site and to develop design criteria for an appropriate remedial action plan for the Site.

#### 1.2.2.3 Interim Cleanup Actions

LRTC has completed two interim cleanups at the Site. The first cleanup action was undertaken in 1986, during the construction of a new train scale in an area north of the former United Heckathorn facilities. During this construction, oily residues containing high concentrations of organic solvents and chlorinated pesticides were detected in a localized area of the shallow fill at the train scale construction site. Approximately 60 cubic yards of chemical-affected material was disposed off site at an approved hazardous waste disposal facility, under DHS oversight, as described in HLA's report entitled "Interim Remedial Action Measures, Train Scale Site Excavation, United Heckathorn Site, Richmond, California" (HLA, 1986a).

LRTC is currently completing a second more extensive interim cleanup along the shoreline area west of the former United Heckathorn facilities. This cleanup is being performed under EPA oversight, in accordance with CERCLA 106 Order 90-22, issued on September 28, 1990, and amended on October 23, 1990. In early November 1990, LRTC, in cooperation with Montrose Chemical Corporation and Rhone-Poulenc Basic Chemicals Company, removed over 800 cubic yards of pesticide-affected soils and sediments. These materials were disposed of at U.S. Ecology's hazardous waste disposal facility near Beatty, Nevada. In addition, EPA has approved the temporary on-site upland containment of an estimated 400 cubic yards of less contaminated sediment, which also was removed from the intertidal zone as part of the current interim cleanup. The final disposal of these sediments will be included as part of the final remedial action plan for the Site. Details of the above interim cleanup action will be provided to EPA as a separate cleanup report, as required by EPA's Order.

## 1.3 Nature and Extent of Contamination

This section summarizes the field work and laboratory analyses completed by Levine•Fricke between October 1989 and December 1990. These activities included a soil-gas survey, soil sampling from shallow pits and deeper borings, and the collection of offshore sediment samples from the Lauritzen Canal and Santa Fe Channel. Additionally, this section reviews the ground-water, ambient air, and biological monitoring data that HLA and others have collected to characterize the extent of contamination in other media at the Site and in the surrounding areas.

The sampling results for each area of the Site are discussed below.

## 1.3.1 UPLAND AREA SOILS

### 1.3.1.1 Soil-Gas Survey

Since solvents are known to have been used at the Site, a soil-gas survey was conducted in the Upland Area to obtain a rapid, preliminary assessment of areas potentially affected by volatile organic compounds (VOCs). Details of this survey are described in Section 3.2.2 of the RI Report. The soil-gas sampling results were then used to identify areas where further soil sampling was warranted.

A total of 58 soil-gas samples were collected and analyzed on site for chlorinated VOCs (1,1,1-trichloroethane [TCA], trichloroethylene [TCE], and tetrachloroethylene [PCE]) and total hydrocarbons (including benzene, ethylbenzene, toluene, and total xylenes). Relatively high chlorinated VOC concentrations were detected over localized areas near the northern side of the former United Heckathorn buildings, where previous solvent usage has been documented. In this area, PCE and TCE concentrations were as high as 40 and 6 $\mu$g/L of soil gas, respectively. In contrast, other areas, including the southern portion of the Site, had chlorinated VOC concentrations that were generally several orders of magnitude lower than the above values.

The soil-gas analyses indicated low or non-detectable non-chlorinated VOC concentrations over most of the Upland Area. The highest non-chlorinated VOC concentrations occurred at sampling point SG-4, at the southern portion of the Site. This location had a total hydrocarbon concentration of 10 $\mu$g/L of soil gas. The surrounding sampling stations, located approximately 50 feet away, had total hydrocarbon concentrations ranging from less than 0.04 to 0.9 $\mu$g/L of soil gas, suggesting that the higher concentrations detected at location SG-4 are present in only a localized area.

All the soil-gas survey data for the Site are presented in Figure 4 and Appendix A of Levine•Fricke's RI Report.

### 1.3.1.2 Soil Sampling Results

Levine•Fricke collected approximately 90 soil samples from 27 borings in the Upland Area during November and December 1989, and an additional 15 samples from five borings in October 1990, to characterize the vertical and horizontal extent of chlorinated pesticide contamination in this part of the Site. Selected samples also were tested for other pesticides, VOCs, semivolatile organic compounds, and total petroleum hydrocarbons (TPH).

These borings generally ranged in depth from 14 to 21.5 feet below grade. Three samples were collected for chemical analyses from each boring. Specific details of this field work are described in Section 3.2.3 of the RI Report. Boring logs showing detailed lithologic descriptions and sampling depths are presented in Appendix B of the RI Report.

Upland soils containing chlorinated pesticides in the low parts per million (ppm) concentration range have been detected over an approximately 6-acre area, extending over the northern half of the Site. These pesticides include DDT, DDD, and DDE (collectively referred to as "total DDT" or "tDDT"); aldrin; dieldrin; endrin; and BHC. While the occurrence of chemical-affected soils at the Site is relatively widespread, soils with higher chlorinated pesticide concentrations (e.g., hundreds to thousands of parts per million) have been detected only over localized areas.

These "hot spot" areas are located in the vicinity of the former United Heckathorn buildings and operations areas where pesticide loading and handling operations are believed to have occurred. For most borings, chlorinated pesticide concentrations were highest in the soil samples collected from the shallow and intermediate depth intervals (e.g., approximately 3 to 6 feet below grade), while much lower chlorinated pesticide concentrations were detected in the deeper samples. The lower concentrations of these compounds in the deeper samples may be due to the type of sediment in the sample (stiff clay), the depth at which it was collected (approximately 9 to 11 feet below grade), and the relative immobility of the chlorinated pesticides in soils at the Site.

Several semivolatile organic compounds (other than chlorinated pesticides) were detected at relatively low concentrations (e.g., approximately 1 ppm or less) in soil samples from the Upland Area. These substances included 2-nitrophenol, pentachlorophenol, 1,2,4-trichlorobenzene, and isophrone, bis(2-chloroisopropyl)ether and di-n-butyl phthalate.

VOCs were not detected in most of the samples analyzed for this class of compounds. However, samples from several borings had VOC concentrations of a few tenths of a part per million. These VOCs included toluene, 1,2-dichloroethene, and tetrachloroethene.

Most of the samples from the Upland Area had TPH concentrations below the detection limit. One sample had a TPH concentration of 700 ppm, which the laboratory characterized as motor oil. However, a duplicate analysis of this sample, and two other samples from this same boring, had TPH concentrations less than the laboratory detection limit of 25 ppm. Thus, the single positive detection from this boring may be the result of laboratory or sampling error, and is not considered representative of actual site conditions.

No organophosphorus pesticides were detected in any upland area soil samples, and chlorinated herbicides were only detected in samples from three borings. The only chlorinated herbicides detected were dichloropropane, 2,4-DB, and dicamba, at concentrations of less than 1.0 ppm.

During HLA's previous remedial investigations at the Site, selected soil samples were analyzed for heavy metals including copper, zinc, nickel, lead and arsenic. These results indicated generally low metal concentrations. Given the widespread occurrence of more toxic chlorinated pesticides at the Site, which were detected at relatively high concentrations, metals have not been identified as a chemical of significant concern in soils, and further sampling for metals was not required as part of the RI/FS at the Site.

### 1.3.2 LAURITZEN CANAL EMBANKMENT SEDIMENTS

Levine•Fricke collected 40 shallow sediment samples during November and December 1989 at 19 sampling stations in the intertidal zone along the eastern embankment of the Lauritzen Canal to characterize the vertical and horizontal extent of pesticide-affected sediments. Approximately 75 additional samples were collected from this area as part of the emergency response action completed between October and December 1990. These sampling results are discussed in detail in Section 3.3 of the RI Report, and are summarized below.

All sediment samples collected from the embankment were analyzed for chlorinated pesticides. At selected locations where drain pipes were observed or where suspected substances or odors were noted, samples were also analyzed for organophosphate pesticides, chlorinated herbicides, semivolatile organic compounds, and VOCs.

The embankment sampling results successfully delineated the length of affected shoreline along the Lauritzen Canal. Laboratory analyses of sediment samples collected from the embankment detected a group of compounds similar to those found in the upland soils. These compounds included aldrin, DDD, DDE, DDT, BHC, and dieldrin.

Embankment sediments with chlorinated pesticide concentrations greater than 1 ppm extend along a corridor from the head of the Lauritzen Canal southward for a distance of approximately 1,200 feet along the shoreline. The highest chlorinated pesticide concentrations (i.e., hundreds of parts per million to percent concentrations) extended over a much more limited shoreline section adjacent to former United Heckathorn Building 1. As detailed in Section 1.2.2.3 above, the embankment area with the highest concentrations was remediated as part of the emergency response cleanup performed in November and December 1990. Chlorinated pesticide concentrations in samples of embankment sediments decreased significantly toward the mouth of the Lauritzen Canal and away from the former United Heckathorn facility.

No organophosphate pesticides, chlorinated herbicides, or TPH were detected in any of the embankment sediment samples tested for these parameters. Several other semivolatile organic compounds were detected in sediment samples collected within the DDT-affected shoreline area. These chemicals included polynuclear aromatic hydrocarbons (PNAs), phenols, chlorobenzenes, and phthalate esters. Concentrations of these chemicals were considerably lower than DDT concentrations, with values less than 1 ppm.

### 1.3.3 GROUND WATER

During HLA's earlier site characterization field work, 12 shallow monitoring wells were installed, developed and sampled to characterize the shallow ground water beneath the Site. The existing water-quality data are described in Section 3.2 of the RI Report and are summarized below.

HLA analyzed ground-water samples from selected monitoring wells for chlorinated pesticides, VOCs, metals, and other EPA priority pollutants. These sampling results indicated generally low or non-detectable concentrations of chemicals in ground water. Chlorinated pesticides were generally detected at concentrations of a few parts per billion (ppb) or less in ground-water samples. As in the upland area soil sampling results, DDT, DDD, and DDE were the most frequently detected pesticides in ground-water samples, and were detected at the highest concentrations. However, these concentrations were typically only a few parts per billion. Almost all of the DDT, DDD, and DDE detected in ground water appeared to be adsorbed to sediment particles, rather than dissolved in the ground water, based on analyses of filtered and unfiltered samples. Both the filtered and unfiltered samples contained aldrin and BHC at concentrations of only a few hundredths of a part per billion.

Although DDT concentrations over 10,000 ppm have been measured in shallow soils at the Site, the relatively low total DDT concentrations detected in ground-water samples may be explained by the extremely low solubility of DDT, DDD, and DDE, and the high sorption coefficients which these chemicals have for soils at the Site.

Neither metals nor VOCs have been detected at significant concentrations in ground-water samples collected at the Site (see Section 3.2.4 of the RI Report). The available data do not indicate that chemicals in ground water are a significant concern, relative to the contamination which has been documented in upland area soils and embankment sediments, and considering the fact that this water's high salinity prevents its use for drinking water and most other purposes.

### 1.3.4 LAURITZEN CANAL OFFSHORE SEDIMENTS, SURFACE WATER, AND BIOTA

#### 1.3.4.1 Offshore Sediments

Offshore sediments in the Lauritzen Canal were sampled to characterize the vertical and horizontal extent of chlorinated pesticides at this part of the Site. Selected samples were also analyzed for organophosphorus pesticides, chlorinated herbicides, TPH, VOCs, and semivolatile organic compounds. Sediment samples were generally collected from depths of approximately 6 to 36 inches in the canal bottom sediments for chemical testing. However, additional sediment samples from depths as great as 10.5 feet below the canal bottom were collected from several of the borings for geotechnical testing and chemical analyses. Sediment analyses data, along with observations made regarding the depth of soft bay sediments, are now sufficient to estimate the extent and volume of Lauritzen Canal sediments affected by pesticides. The most commonly detected chemicals in the Lauritzen Canal sediments were aldrin, DDD, DDE, DDT, and dieldrin. Chlorinated pesticide concentrations in canal sediments generally decreased from the head to the mouth of the canal. Concentrations of chlorinated pesticides detected in sediment samples collected from the head of the canal ranged as high as approximately 700 ppm (HLA, 1986b). Over the middle section of the canal, chlorinated pesticide concentrations ranged from a few ppm to approximately 2,000 ppm in the area immediately offshore of the former United Heckathorn Facility (Levine•Fricke, 1990b). Chlorinated pesticide concentrations near the mouth of the Lauritzen Canal were much lower, ranging from below detection limits up to approximately 0.5 ppm. At several locations in the northern half of the canal, chlorinated pesticide concentrations were observed to increase with depth.

No organophosphorus pesticides, chlorinated herbicides, VOCs or TPH were detected in Lauritzen Canal sediment samples. Concentrations of PNAs and other semivolatile organic compounds were detected in canal sediment samples from a few locations but at lower concentrations than those reported for chlorinated pesticides.

1.3.4.2 Surface Water

Baseline water quality monitoring was completed as part of the emergency response cleanup performed in late 1990. Water samples were collected from five sampling stations in the Lauritzen Canal and Santa Fe Channel. At each station, samples were collected at the surface, mid-depth, and the bottom of the water column. Both filtered and unfiltered samples were analyzed for chlorinated pesticides using EPA Method 608. No pesticides were detected in any of the samples. These data are consistent with the extremely low solubility for DDT and the other chlorinated pesticides detected in soils and sediment at the Site.

1.3.4.3 Lauritzen Canal Biota

Section 3.4.2 of the RI Report discusses the extent of contamination in aquatic organisms in Lauritzen Canal waters, based on historical data and more recent bioaccumulation monitoring results for fish, shellfish, and other aquatic organisms. These data are summarized below.

In 1984, Aqua Terra Technologies of Oakland, California (Aqua Terra) analyzed tissue samples from mussels, crabs, and polychaetes for DDT, DDD, and DDE, as part of its biological monitoring program at the Site. The highest concentrations detected, expressed as the sum of these three compounds (total DDT or tDDT), were as follows: polychaete = 100.5 ppm, mussel = 26.2 ppm, crab = 5.67 ppm, and clam = 12.85 ppm.

In 1986, Aqua Terra analyzed composite tissue samples from native Bay mussels (Mytilis edulis) collected from three locations in the Lauritzen Canal, and one location near the head of the Santa Fe Channel. These samples were analyzed for organochlorine pesticides and other semivolatile organic compounds. Besides chlorinated pesticides, no semivolatile organic compounds were detected in any of the composite tissue samples.

The highest pesticide concentrations were reported for the composite tissue sample from Station 1, located at the northern end of the Lauritzen Canal. At this location, total DDT concentrations were 8.3 ppm. The composite sample from this station also had the highest concentrations of other chlorinated pesticides, including aldrin (0.03 ppm), dieldrin (1.2 ppm), endrin (0.19 ppm), and g-BHC (0.046 ppm). Consistent with the general concentration gradient observed for Lauritzen Canal sediments, chlorinated pesticide concentrations in mussels decreased significantly with distance from this station. For example, total DDT concentrations of 1.4 ppm and 0.10 ppm were detected in mussel samples collected from the middle and southern sections of Lauritzen Canal.

In addition to the shellfish analyses described above, the State of California performed mussel monitoring in the middle of the Lauritzen Canal (Station 303.3) as part of the State Mussel Watch Program in 1986 and 1987. During the 1985-86 Mussel Watch Program, a total DDT concentration of 2.83 ppm (wet-weight basis) was detected in resident edible mussels collected from the Lauritzen Canal. During the 1986-87 Mussel Watch Program, a total DDT concentration of 12 ppm (wet-weight) was detected in transplanted mussels deployed at Station 303.3. Other chlorinated pesticides detected in resident or transplanted mussels from the Lauritzen Canal included aldrin, dieldrin, endrin, total chlordane, heptachlor, toxaphene, a-BHC, g-BHC, and d-BHC. The tissue concentrations of these other chlorinated pesticides were consistently lower than the total DDT concentrations for Lauritzen Canal samples.

In addition to the shellfish monitoring described above, in June 1986, the members of United Anglers Association caught several fish from the Lauritzen Canal as part of an independent sampling effort. The United Anglers Association submitted its samples to the CDFG for tissue analyses. The highest DDT concentration detected from these samples was 13.6 ppm, based on the whole-body analysis of a shiner surf perch.

## 1.3.5 SANTA FE CHANNEL OFFSHORE SEDIMENTS AND BIOTA

### 1.3.5.1 Offshore Sediments

As part of Levine•Fricke's 1989-90 field work, shallow sediment sampling was conducted in the Santa Fe Channel to characterize the vertical and horizontal distribution of chlorinated pesticides in that area. Sediment samples were collected from the channel bottom at a depth of 4 inches at 21 locations. Deeper samples, from depths of 28 and 48 inches below the channel bottom, were also collected from selected sampling locations to assess the vertical distribution of chlorinated pesticides in deeper sediments of the channel.

The chlorinated pesticides detected in the Santa Fe Channel sediment samples included DDT, DDD, DDE, and dieldrin. Neither aldrin nor endrin were detected in Santa Fe Channel sediment samples. At most sampling locations, DDT, DDE, and DDD concentrations ranged from only a few parts ppb to a few tenths of a part per million. However, three samples (SFC-4-4, SFC-13-48, and SFC-17-4) contained DDD concentrations slightly greater than 1 ppm. Although most samples contained dieldrin concentrations of a few ppb, the three samples with the highest DDT concentrations also contained relatively high dieldrin concentrations, which ranged from 0.182 ppm to 0.368 ppm.

No consistent trends regarding vertical or lateral distribution of chlorinated pesticides are apparent from the sediment data. The sampling locations with the highest pesticide concentrations were located relatively far apart from one another, near the head of the channel (SFC-4) and its junction with the Lauritzen Canal (SFC-13 and SFC-17). At six of the sampling locations, samples were collected at two or more depths. Depending on the particular boring location, DDD concentrations were observed either to increase with depth or to remain approximately constant with depth.

### 1.3.5.2 Biota

The extent of contamination in the Santa Fe Channel biota has been characterized based on Aqua Terra's biological monitoring program and the bioconcentration data generated as part of the State Mussel Watch program. These sampling programs are discussed in Section 3.5.2 of the RI Report, and are summarized below.

In 1986, Aqua Terra detected a total DDT concentration of 0.056 ppm in native Bay mussels (Mytilis edulis) collected from a sampling station near the head of the Santa Fe Channel. The only other chlorinated pesticides detected in this composite sample were aldrin (0.00014 ppm) and heptachlor (0.00013 ppm). No other semivolatile organic compounds were detected in any of the composite tissue samples.

Other shellfish monitoring data for the Santa Fe Channel are available from the State Mussel Watch Program. As part of this program, the State has measured the concentrations of pesticides in mussels deployed near the head of the Santa Fe Channel (Station 303.2) (1985, 1986, and 1987), and near the Santa Fe Channel's junction with the Lauritzen Canal (Station 303.4) (1986 and 1987). The highest total DDT concentrations measured at Stations 303.2 and 303.4 were 1.36 ppm and 1.63 ppm, respectively (wet-weight basis). Other chlorinated pesticides detected at one or both of these stations included aldrin, chlordane, dieldrin, endrin, a-BHC, g-BHC, d-BHC, and toxaphene. The wet-weight concentrations of these other pesticides were one to several orders of magnitude lower than total DDT concentrations, and were consistently lower than the pesticide concentrations reported for mussel tissue samples from the Lauritzen Canal sampling station.

### 1.3.6 AMBIENT AIR

The concentrations of DDT, other chlorinated pesticides, and selected metals in ambient air at the Site have been characterized through previous air monitoring activities performed by EAL Corporation of Richmond, California, and Ecology and Environment of San Francisco, California. These investigations are reviewed in Section 3.2.5 of the RI Report and are summarized below.

In June 1983, EAL collected a total of 14 ambient air samples at locations adjacent to the former United Heckathorn facility, in an area known to be contaminated with relatively high concentrations of DDT. Additionally, one sample was collected at an upwind station near the LRTC office, located southeast of the former United Heckathorn facility. All but one of the 14 samples collected during this initial sampling phase had DDT concentrations less than 100 nanograms/cubic meter (ng/$m^3$). The highest value reported was 100 ng/$m^3$, which is one ten-thousandth of the permissible exposure limit (PEL) of 1 mg/$m^3$ (1,000,000 ng/$m^3$) established by the Occupational Health and Safety Administration (OSHA) for occupational exposures.

EAL conducted a second phase of air monitoring in 1984. As with the 1983 sampling phase, air samplers were placed at locations adjacent to the former United Heckathorn facility. A total of six air samples were collected on glass fiber filters. These samples were analyzed for DDT, DDD, DDE, arsenic, copper, lead, nickel, zinc, and total particulates. The highest DDT concentration reported for this sampling phase was 1.38 ng/$m^3$, a value of approximately one millionth of the OSHA PEL for DDT. The highest reported metals concentrations were as follows: arsenic, less than 0.007 $\mu$g/$m^3$; copper, 0.37 $\mu$g/$m^3$; lead, 0.64 $\mu$g/$m^3$; nickel, 0.09 $\mu$g/$m^3$; and zinc, 1.32 $\mu$g/$m^3$. These values are all considerably lower than their respective PELs set by OSHA and are consistent with the relatively low metal concentrations detected in upland soils at the Site.

In 1988, Ecology and Environment performed air monitoring at the Site and several off-site locations, under contract to EPA. Air samples were collected at three on-site locations near the former United Heckathorn facility, at one upwind location near the southern boundary of LRTC's facility, and at two off-site stations located approximately 0.125 mile and 0.25 mile downwind from the Site. Air samples were analyzed for organochlorine pesticides using EPA Method 608. DDT, DDE, DDD, dieldrin, and endrin were the only pesticides for which data were reported. Other organochlorine pesticides either were not detected or were detected but determined to be laboratory contaminants.

The highest airborne DDT concentration reported by Ecology and Environment was 310 ng/$m^3$, detected near an on-site location with the highest known soil contamination. The remainder of Ecology and Environment's air sampling data were considerably lower than this value. Geometric mean DDT concentrations for samples collected at other on-site sampling stations in the vicinity of the former United Heckathorn facility ranged from 1.3 ng/$m^3$ up to 4.8 ng/$m^3$. All of the above values were at least several orders of magnitude lower than the OSHA PEL of 1 mg/$m^3$, established for occupational exposure to DDT.

Dieldrin and endrin concentrations detected in on-site air samples were consistently lower than DDT concentrations. The highest reported dieldrin concentration was 14 ng/$m^3$, and the highest reported endrin concentration was 11 ng/$m^3$. As with DDT, both of these values are orders of magnitude below the OSHA PELs established for dieldrin and endrin (0.25 mg/$m^3$ and 0.1 mg/$m^3$, respectively).

Samples which Ecology and Environment collected from the upwind station had an average DDT concentration ranging from 0.096 to 0.40 ng/$m^3$. Average DDT concentrations reported for the two downwind stations ranged from 0.58 to 1.1 ng/$m^3$. These concentrations are approximately one order of magnitude higher than the data collected upwind of the Site. The potential migration of DDT and the potential human health risks due to airborne chemical emissions from the Site are evaluated further in Sections 4.0 and 5.0 of the RI Report.

## 1.4 Contaminant Fate and Transport

Section 4.0 of the RI Report reviews the potential routes of migration and environmental fate of the chemicals detected at the Site. Major points from the RI Report are summarized below.

As previously noted, the highest pesticide concentrations were detected in upland area and embankment soils near the former United Heckathorn facility. Percent-range concentrations of DDT were detected in a localized portion of shallow subsurface fill materials along the west side of the former United Heckathorn facility. Similarly high DDT concentrations were detected in embankment sediments located downslope from this upland "hot-spot" area. As previously noted, most of these highly contaminated sediments were excavated and removed from the Site during LRTC's interim soil cleanup in November 1990.

Based on a review of historical aerial photographs and other background documents, it appears that these "hot spot" areas were primarily due to the direct spillage of pesticides that were stored and processed at the United Heckathorn facility. Since the upland and embankment areas have been documented to contain the highest pesticide concentrations, the potential transport of contaminants from these locations to other environmental media (i.e., ambient air, ground water, and Lauritzen Canal water and benthic sediments) has been evaluated for the Site.

### 1.4.1 MIGRATION OF CHEMICALS FROM SOIL INTO THE ATMOSPHERE

Based on the low Henry's Law of Constants and low solubilities of the chlorinated pesticides detected in upland and embankment areas of the Site, these chemicals would remain adsorbed to soils and sediments rather than volatilizing into the atmosphere. These soils consist primarily of Bay Mud overlain by sandy gravel fill material. Although the area surrounding the former United Heckathorn facility is unpaved, LRTC has placed clean gravel over the upland surfaces containing the highest DDT concentrations. This surface coverage would significantly limit the potential for air erosion of contaminated soils and fill material in the Upland Area. Moreover, the highest pesticide concentrations have been detected at depths of approximately 6 feet below the ground surface.

Since the embankment area is adjacent to the Lauritzen Canal, the embankment sediments tend to be saturated with water. Additionally, most of the embankment area is covered with riprap materials and overlain with a pile-supported wharf structure. These features significantly reduce or eliminate the potential for wind erosion of contaminated embankment sediments.

Based on the above factors, there appears to be very limited potential for chlorinated pesticides to be transported from soils to ambient air at the Site. Both the chemical properties of these chemicals and the environmental characteristics of the Site indicate that volatilization and wind-blown dispersal are not significant migration pathways under current site conditions. The low potential for contaminant transport by this pathway is supported by the air monitoring data presented in Section 1.3.6 of this document. Airborne DDT concentrations have been detected at very low concentrations (typically on the order of a few $ng/m^3$).

### 1.4.2 MIGRATION OF CHEMICALS FROM THE VADOSE ZONE INTO GROUND WATER

There are three general mechanisms for the transport of chemicals from vadose-zone soils to ground water. Water-soluble chemicals may dissolve into soil moisture and percolate through the vadose zone into ground water. Chemicals in liquid form may also migrate as free product through the vadose zone. Theoretically, chemicals which are relatively insoluble could become adsorbed onto fine sediments, which might then be transported downward into the ground water. The chemical factors affecting these transport mechanisms include solubility, soil adsorption constant, and the octanal-water partition coefficient. Site conditions which also influence these potential transport mechanisms include distance to ground water, soil permeability, and hydraulic conductivity.

The chlorinated pesticides detected at the Site are characterized by a very low solubility. For example, the maximum reported solubility of DDT is only 0.025 ppm. Thus, migration of these chemicals into ground water via dissolution in soil moisture would be minimal.

The depth to ground water at the Site is approximately 5 to 10 feet below ground surface. This shallow depth suggests that chlorinated pesticides that are adsorbed to surface sediments could infiltrate into ground water. While this mechanism is possible for vertical movement, the horizontal transport of these sediments over significant distances would be much less likely to occur, given the relatively low gradients (0.0092 to 0.038) and hydraulic conductivities (0.00073 to 0.00083 cm/sec) which have been reported for fill materials at the Site (HLA, 1986). Chemical-affected fine sediments would probably become immobilized within the interstitial spaces of the saturated zone, preventing significant horizontal transport. Consistent with these site conditions, as well as the very low solubilities and high soil adsorption coefficients of these chemicals, little or none of these particles have been detected in ground water at the Site.

In summary, there appears to be very limited potential for the chlorinated hydrocarbon pesticides detected in upland area soils to migrate significantly in ground water. These compounds are virtually insoluble in water, and typically become highly adsorbed onto soil particles, which would be expected to remain relatively immobile at the Site. Consistent with these characteristics, the available ground-water monitoring data indicate very low or non-detectable concentrations of chlorinated pesticides (e.g., typically only a few ppb or less).

### 1.4.3 MIGRATION OF CHEMICALS TO THE LAURITZEN CANAL

The historical discharge of process wastewater and the spillage of chemicals during previous pesticide manufacturing and formulating activities are believed to be the two primary routes by which chemicals have been released to the Lauritzen Canal. Other relatively minor transport mechanisms include the seepage of chemical-affected ground water into the Lauritzen Canal and the overland flow of existing surface runoff from the Upland Area into the Lauritzen Canal. As noted above, the chlorinated pesticides detected at the Site are not readily transported via ground water, based on chemical and environmental factors.

The overland flow of contaminated sediments into the Lauritzen Canal is also not believed to be a pathway of concern due to the relatively flat topography of the Site. Observations at the Site conducted by Levine•Fricke after relatively heavy rains did not reveal the presence of rills, rivulets, or gullies. These surface erosional features would be indicative of erosion of surface soils from overland drainage of precipitation. In contrast, ponding was observed in those areas where precipitation had not rapidly infiltrated into the soil. Ponded water would gradually evaporate or soak into the ground, as opposed to draining via runoff to the Lauritzen Canal.

Thus, it appears likely that the chlorinated pesticides detected in the Lauritzen Canal were discharged into the canal during past site usage. The low solubility and high adsorption characteristics of these chemicals suggest that, once in the canal, these chemicals would remain adsorbed onto particulate matter which may then settle out of the water column to form benthic sediments.

These benthic sediments could become resuspended and transported in the water column during times of turbulence. However, this effect would be offset by the deposition of additional sediments deposited in the Lauritzen Canal via surface runoff from other off-site areas. Without periodic dredging, the Lauritzen Canal would continue to fill with sediments, which would tend to cover the underlying chemical-affected sediments.

## 1.5 Public Health Evaluation

### 1.5.1 INTRODUCTION

Section 5.1 of the RI Report presents a qualitative PHE for the Site. The PHE results were used to develop remedial action objectives and a range of remedial alternatives for the Site, including the "no action" alternative, as required by CERCLA. Key elements of the PHE include the identification of chemicals of potential concern, a review of these chemicals' toxicity, the identification of potential exposure pathways to the general public, and a discussion of the potential human health risks resulting from exposure to these substances. The principal findings of the PHE are summarized below.

1.5.2 SELECTION OF INDICATOR CHEMICALS

To focus the PHE and subsequent feasibility study analyses on those chemicals which pose the greatest risk to human health, all of the chemicals detected at the Site during LRTC's 1989-90 field work were reviewed using the following criteria: frequency of detection, concentration, and relative toxicity. The sampling results for upland area soils, embankment sediments, and offshore sediments were separately tabulated to list every chemical which has been detected in these media, as shown in Tables 5-1 through 5-4 of the RI Report. The following trends are apparent from this evaluation:

1. Organochlorine pesticides were the most frequently detected chemicals at the Site. These chemicals were detected over a widespread area which encompassed the more localized distributions of all other chemicals detected at the Site.

2. No organophosphorus pesticides were detected in samples from any areas of the Site. Chlorinated herbicides were not detected in any embankment or offshore sediment samples, and were detected at low concentrations (less than 1 ppm) in only two upland samples. No VOCs were detected in Lauritzen Canal offshore sediments, and only a few VOCs, at relatively low concentrations, were detected in upland area soil and embankment sediment samples.

3. Several semivolatile organic compounds other than chlorinated pesticides were detected in upland area soils, embankment sediments, and offshore sediments at the Site. However, these compounds were not selected as indicator chemicals, since they were detected at relatively low concentrations (generally less than 1 ppm), in areas where chlorinated pesticides were detected at much higher concentrations.

Table 1-2 summarizes the indicator chemicals selected for each sampling area at the Site. For the upland and embankment areas, these chemicals include aldrin, DDD, DDE, DDT, dieldrin, endrin, chlordane, and BHC. For the Lauritzen Canal offshore sediments, the indicator chemicals include DDT, DDE, DDD, and dieldrin. No indicator chemicals have been identified for sediment samples from the Santa Fe Channel, given the relatively low pesticide concentrations detected in that location.

### 1.5.3 POTENTIAL HUMAN EXPOSURE PATHWAYS

For a chemical to pose a human health risk, a complete exposure pathway must exist. A complete exposure pathway consists of four elements:

- A source and mechanism of chemical release to the environment.
- An environmental transport medium (e.g., air or surface water) for the released chemical.
- A point of human contact with the contaminated medium (known as the exposure point).
- A human exposure route (e.g., inhalation, ingestion, or dermal contact) at the exposure point.

Possible exposure scenarios under current- and future-use conditions are evaluated in Section 5.1.4 of the RI Report. The following discussion summarizes the potential exposure pathways which were considered in the PHE for the Site. The environmental media considered include upland area soils, embankment sediments, ground water, ambient air, offshore sediments, and aquatic organisms in the Lauritzen Canal.

#### 1.5.3.1 Soil and Ground-Water Exposure Pathways

Potential exposures resulting from the direct contact with chemicals in upland soils and embankment sediments are believed to present an insignificant public health risk due to site access and land use restrictions associated with the Site's current and expected future use as a marine shipping terminal. Similarly, potential exposures to chemicals in ground water are believed to have no significant impact on human health, since no exposure points (e.g., water supply wells) or exposure routes (e.g., ingestion) for ground water currently exist. Moreover, due to the brackish nature of ground water at the Site, and the extremely low solubility of the indicator chemicals in water, future exposure pathways involving ground water are expected to be incomplete. Thus, soil and ground-water exposure pathways have been screened out from further risk evaluations.

#### 1.5.3.2 Air Pathway

The chlorinated pesticides identified as indicator chemicals would be expected to adhere to soil particles which potentially could be eroded by strong winds or heavy equipment operations at the Site. Such fugitive dust emissions could potentially expose individuals living or working downwind of the Site to the indicator chemicals. The nearest residences are located approximately 0.25 mile away from the Site, and commercial businesses are located on properties adjacent to the Site.

As noted in Section 3.2.5 of the RI Report, the release of DDT to ambient air has been documented at the Site, although the reported concentrations were several orders of magnitude below regulatory limits for occupational exposure. Nevertheless, since this pathway may be complete, it has been retained in the PHE, and the potential risks of this pathway have been further evaluated.

1.5.3.3 Lauritzen Canal Pathway

Previous sampling results for fish and shellfish collected from the Lauritzen Canal waters have indicated that these animals may bioconcentrate the indicator chemicals. The ingestion of seafood which has bioconcentrated chlorinated pesticides from the Lauritzen Canal could present a human health risk. Although this potential exposure pathway has not been documented, it has been retained for the PHE. The potential health risks associated with these two pathways are discussed below.

1.5.4 CHARACTERIZATION OF HUMAN HEALTH RISKS

1.5.4.1 Air Pathway

Air monitoring activities have detected generally low chlorinated pesticide concentrations (e.g., on the order of a few nanograms per cubic meter or less) at the Site and surrounding locations. Although a detailed evaluation of occupational exposure risks was outside the scope of this PHE, it should be noted that the highest airborne DDT concentration detected at the Site (310 $ng/m^3$, detected at a part of the Site where soils contain substantially elevated pesticide concentrations) is many orders of magnitude lower than the OSHA PEL of 1 $mg/m^3$ (1,000,000 $ng/m^3$) which has been established for DDT. Since the OSHA standard is based on an 8-hour time-weighted exposure, the PEL would not be directly comparable to the reported air monitoring data. Nevertheless, the airborne DDT concentrations measured at the Site are so much lower than the PEL that one may reasonably conclude that ambient airborne DDT concentrations present a negligible occupational exposure risk to LRTC employees.

The available off-site air monitoring data were used for a screening-level assessment of the potential health risks to downwind residential receptors. Air monitoring data have indicated average airborne DDT concentrations of approximately 1 $ng/m^3$ or less at sampling stations downwind of the Site. Based on these data, and the standard exposure assumptions and toxicologic values described in Section 5.1.5 of the RI Report, the potential excess lifetime cancer risk due to DDT exposure to downwind residential populations was estimated to be $1.1 \times 10^{-7}$. This value is less than the risk range of $10^{-4}$ to $10^{-6}$ which EPA generally uses to establish health-protective cleanup goals at Superfund sites. Based on this calculation, inhalation exposures to DDT are believed to present a relatively minor or insignificant health risk to potential receptors located downwind of the Site.

1.5.4.2 Ingestion of Seafood

Since estuarine organisms in the Lauritzen Canal have been shown to bioconcentrate DDT, the consumption of pesticide-affected seafood has been identified as a potential exposure pathway for the Site. However, given the current and expected future use of this water body as a shipping channel, the absence of public access routes along the Lauritzen Canal, and the availability of other more suitable fishing areas in the site vicinity, it is unlikely that persons would obtain fish or shellfish from the Lauritzen Canal. Additionally, it should be noted that the canal is currently posted with warning signs which state that shellfish and fish may be contaminated with DDT. For the reasons stated above, a more likely human exposure pathway would be the consumption of fish collected outside the Lauritzen Canal which have bioconcentrated chlorinated pesticides while occasionally feeding on prey species or offshore sediments in the Lauritzen Canal.

The Food and Drug Administration (FDA) has established action levels for several chlorinated pesticides, including aldrin, dieldrin, DDT, DDD, DDE, endrin, and chlordane. These action levels represent specific concentrations at or above which the FDA will take legal action to remove pesticide-affected seafood from the market. Since the FDA action levels apply to the commercial sale of seafood, they are not regulatory levels for such activities as sport fishing, crabbing, or non-commercial shellfish harvesting. However, since the FDA action levels were established as health-protective standards, they are considered to be generally applicable to the consumption of seafood, regardless of its commercial or non-commercial origin.

The available data on pesticide concentrations in estuarine organisms collected from the Lauritzen Canal and Santa Fe Channel have been compared to the FDA action levels as an indication of their potential human health risks.

Whole fish, crab tissue, and shellfish collected from the Lauritzen Canal have been found to contain DDT concentrations which exceed the FDA action level of 5 ppm for the edible portion of fish. Shellfish collected from the Lauritzen Canal have been found to contain dieldrin at a concentration which exceeds the FDA action level of 0.3 ppm for the edible portion of fish. No shellfish with pesticide concentrations exceeding the FDA action levels for fish or shellfish have been collected from the Santa Fe Channel. The lower pesticide concentrations which have been reported for Santa Fe Channel mussels are consistent with the lower pesticide concentrations measured in Santa Fe Channel offshore sediments, compared to Lauritzen Canal biota and sediment.

Although several organisms collected from the Lauritzen Canal have been reported to contain chlorinated pesticides at concentrations greater than the FDA action levels, it is unlikely that this exposure pathway would be complete, because of the limited accessibility and industrial nature of this shipping channel, and the presence of warning signs the canal. Since estuarine species obtained from the Santa Fe Channel have not been found to contain indicator chemicals at concentrations greater than FDA action levels, the actual human health risks for this exposure pathway are believed to be minor.

### 1.6 Environmental Evaluation

As discussed in Section 5.2 of the RI Report, the chlorinated pesticides identified as indicator chemicals have been shown to bioaccumulate in estuarine organisms, including shellfish and fish. The RI Report's environmental evaluation included three elements. First, sediment quality data for the San Francisco Bay-Delta and for the Santa Fe Channel were reviewed to identify regional background concentrations for the indicator chemicals. Second, the indicator chemical concentrations reported for estuarine species collected at the Site were compared to data from other Bay Area locations. Third, literature on the acute and chronic toxicity of the chlorinated pesticides was reviewed to predict possible physiological effects to the estuarine ecosystem and its organisms. The results of this environmental evaluation, along with the PHE analyses, have been used to develop remedial action objectives and cleanup alternatives for the Site.

The remedial investigation data for the Site, including sediment chemistry results, tissue analyses of marine organisms, and other biological monitoring data, indicate that the chlorinated pesticides identified as indicator chemicals for the Site may be adversely affecting the aquatic habitat in the Lauritzen Canal. Although there are not sufficient data to quantify the extent to which these pesticides have actually impacted this part of the Site, the following observations can be made:

1. Offshore sediments in the Lauritzen Canal have tDDT and dieldrin concentrations which are notably higher than the concentrations reported for other parts of the Bay Area. The average tDDT concentration detected in surficial sediments (i.e., upper 6 inches) in the Lauritzen Canal is 11.2 ppm, approximately 60 times higher than the average value of 0.19 ppm which has been reported for other peripheral waterways in the Bay Area.

2. Resident and transplanted mussels collected from the Lauritzen Canal also have tDDT and dieldrin concentrations which are notably higher than the concentrations reported for samples collected from other stations in the Bay Area. The average TDDT concentration for mussel samples collected from the Lauritzen Canal was 7.43 ppm, which is approximately 270 times higher than the average value of 0.028 ppm reported for all other sampling locations from San Francisco Bay (excluding the Santa Fe Channel).

3. The limited data which are available suggest that Lauritzen Canal sediments may be acutely toxic to at least some organisms. This interpretation of the data is consistent with the relatively low species diversity (two to five species per sampling location) which has been reported for sediment samples collected from the Lauritzen Canal.

4. While Santa Fe Channel sediments and shellfish also contain TDDT at elevated concentrations relative to average concentrations for the Bay Area, they are considerably lower than the sampling results obtained for stations in the Lauritzen Canal. The average tDDT concentration of surficial sediments collected from the

Santa Fe Channel (i.e., upper 4 inches) was 0.37 ppm, and the average mussel tissue concentration of tDDT was 0.962 ppm for this waterway.

# 2.0 DEVELOPMENT OF REMEDIAL ACTION OBJECTIVES

## 2.1 Introduction

Remedial action objectives are specific goals for protecting human health and the environment. These objectives specify indicator chemicals, potential exposure routes and receptors, and cleanup goals for the Site. The remedial action objectives developed in this part of the FS Report are based on RI sampling results, an evaluation of potential human health and environmental risks, and a review of ARARs for the Site.

The environmental sampling results for the Site are presented in detail in the RI Report, and are summarized in Section 1.3 of this FS Report. These data were used as input for the PHE and environmental risk evaluation presented in Section 5.0 of the RI Report and summarized in Section 1.0 of this FS Report. ARARs for the Site are discussed below, followed by a discussion of the specific remedial action objectives which have been developed for this FS Report.

## 2.2 Applicable or Relevant and Appropriate Requirements

### 2.2.1 INTRODUCTION

SARA requires that remedial actions at a Superfund site achieve a level of cleanup that protects human health and the environment. In addition, the cleanup must attain "legally applicable or relevant and appropriate" requirements (ARARs) which are promulgated under federal or State law. The ARARs for the Site provide requirements against which the remedial action alternatives are reviewed; the selected alternative must meet the ARARs unless a waiver (as described below) is warranted.

An applicable requirement is a promulgated federal or State standard that specifically addresses a hazardous constituent, remedial action, location, or other circumstance at a CERCLA site. For a requirement to be applicable, the remedial actions or the circumstances at the site must be within the intended scope and authority of the requirement. For example, Maximum Contaminant Levels (MCLs) are drinking water standards which must be met by owners/operators of public drinking water supply systems. The standards are applicable "at the tap" for water supplied by a public water supply system and are enforced either by the State or EPA.

A relevant and appropriate requirement is a promulgated federal or State requirement which addresses problems or situations sufficiently similar to those encountered at a Superfund site, even though the requirement is not legally applicable. For example, MCLs may be judged to be relevant and appropriate for ground-water remedial goals if the ground water is used for drinking water. As noted above, however, the MCLs would not be applicable to ambient ground-water quality since the MCLs are "at the tap" standards.

A requirement may be relevant but not appropriate given site-specific circumstances; such a requirement would not be an ARAR for the Site. An example of this situation is the Resource Recovery and Conservation Act (RCRA) requirements for landfill closure which require the site to be capped with a final cover designed and constructed to provide long-term minimization of the migration of liquids through the capped area. If the remedial action includes an on-site landfill area, the wastes are largely immobile, and there will be no threat of direct contact, the requirement for an impermeable cover may be relevant but would not be appropriate (EPA, August 1988b, p. 1-68).

A requirement that is considered to be relevant and appropriate must be complied with to the same degree as if it were applicable. However, if only part of a requirement is relevant and appropriate for a particular site, that portion which is not considered relevant and appropriate can be dismissed.

Federal and State non-promulgated standards, policies, advisories, or guidance documents, and local requirements, are not ARARs. However, these guidelines may be considered when determining remedial actions to protect human health and the environment. These criteria are called "To Be Considered" or "TBC" factors.

Section 121(e) of SARA provides that federal, State, and local permits are not required for the portion of any removal or remedial action conducted entirely on site, when the action is selected and carried out in compliance with Section 121 of SARA. However, substantive requirements of federal, State, or local environmental law (usually expressed as permit requirements) must be met because a state or local entity may enforce those requirements. "On site" is defined as the areal extent of contamination and all suitable areas in very close proximity to the contamination necessary for implementation of the response action [40 CFR 300.5 and 300.400(e)(1)].

Waivers
Section 121(d)(4) of SARA provides that the President may select a remedial action that does not achieve a level or standard of control at least equivalent to an ARAR if the President finds that one or more of the following six conditions warrants a waiver from the ARARs:

- The remedial action selected is only part of the total remedial action that will attain such level or standard of control when completed.
- Compliance with the ARAR will result in greater risk to human health and the environment than alternative options.
- Compliance is technically impracticable from an engineering perspective.
- The remedial action selected will attain a standard of performance equivalent to an ARAR through use of another method or approach.
- The State has not consistently applied the standard, requirement, criterion, or limitation in similar circumstances at other remedial actions within the State.
- The ARAR would require too great an expenditure from the Superfund Trust Fund. (This applies solely to remedial actions taken under Section 104 of SARA, Using the Superfund Trust Fund.)

If any of the above conditions are met, the agency to whom the President's authority has been delegated may waive ARARs as long as the proposed remedial actions are protective of human health and the environment. A determination to grant a waiver can be made during the implementation of the selected remedial alternative.

Types of ARARS
There are three types of ARARs: chemical-specific ARARs, action-specific ARARs, and location-specific ARARs. These general categories are described below, followed by a discussion of possible ARARs for the Site.

Chemical-specific ARARs are usually health- or risk-based concentration limits for specific hazardous substances in various environmental media (e.g., air, soil, ground water) at the Site. Examples of this type of ARAR are State water-quality standards or National Ambient Air Quality

Standards. Chemical-specific ARARs may be used as input to establish protective cleanup levels for the site or to develop acceptable limits for remedial alternatives which involve the discharge of chemicals to surface water or other environmental media.

Action-specific ARARs are technology-based requirements which are triggered by the type of remedial activities under consideration. These types of ARARs may affect the technology, design, or performance of remedial alternatives. Examples of this type of ARAR are land disposal restrictions developed under the Hazardous and Solid Waste Amendments of 1984 (HSWA).

Location-specific ARARs impose restrictions on certain types of activities, based on site characteristics. Examples of location-specific ARARs include federal and State citing laws for hazardous waste facilities (e.g., proximity to flood plains or active faults).

### 2.2.2 CHEMICAL-SPECIFIC ARARS

As previously noted, chemical-specific ARARs are generally health or risk-based standards which apply to particular chemical constituents and environmental media at the Site. Potential chemical-specific ARARs have been reviewed for the chlorinated pesticides selected as indicator chemicals for the Site. The media considered in this evaluation include soils and sediments, surface water, ground water, air, and seafood.

#### 2.2.2.1 Soil and Sediments

No chemical-specific ARARs have been identified as remedial goals for upland soils, embankment sediments, and offshore sediments at the Site. However, DHS has developed chemical-specific regulatory criteria for the identification of hazardous and extremely hazardous wastes, based on Total Threshold Limit Concentration (TTLC) and Soluble Threshold Limit Concentration (STLC) values (California Code of Regulations, Title 22, Sections 66699 and 66723). Table 2-1 lists the TTLCs and STLCs which have been defined for indicator chemicals at the Site. The TTLCs and STLCs do not represent cleanup levels; however, soils and sediments with chemical concentrations higher than the TTLCs or STLCs would be classified as hazardous or extremely hazardous under State law.

Similarly, under the RCRA, EPA has developed chemical-specific criteria for the identification of hazardous waste. For most of the indicator chemicals at this Site, the criteria are not concentration based, but are instead based on the source and presence of the constituents [40 CFR 261.33 (d)]. EPA has also developed concentration-based criteria for identifying characteristic wastes which include endrin, chlordane, and lindane. The criteria are based on the analytical results of the EP Toxicity Test until September 25, 1990. New criteria are applicable to large quantity generators of waste on September 25, 1990 (FR vol. 55, p. 11798) and are based on the analytical results of waste using the Toxicity Characteristic Leaching Procedure (TCLP). Wastes that contain constituents in concentrations greater than those shown in Table 2-1 would be characteristic RCRA hazardous wastes.

Based on the review of historical documents, the presence of the indicator chemicals in the soils appears to be due to spills of commercial chemical products or manufacturing chemical intermediates; the presence of the indicator chemicals in the Lauritzen Canal sediments appears to be primarily due to releases of wastewater from the manufacturing process. EP Toxicity and TCLP analyses have not been performed on soil or sediments at the Site. However, based on the results of other leaching procedures, soils and sediments are not expected to contain indicator chemicals in excess of the TCLP values or the EP Toxicity values.

For purposes of this FS, the upland soils and embankment sediments affected by indicator chemicals are considered to be RCRA wastes, and the offshore sediments are considered to be non-RCRA wastes.

These chemical-specific criteria developed by DHS and EPA trigger action-specific ARARs which are discussed in Section 2.2.3 of this report.

#### <u>2.2.2.2 Surface Water</u>

The RWQCB has established water-quality objectives for inland surface waters, including enclosed bays and estuaries, pursuant to the Porter-Cologne Water Quality Control Act. These water-quality objectives are contained in the Water Quality Control Plan for the San Francisco Bay Region (Basin Plan) (RWQCB, 1986). The Basin Plan contains a toxicity objective, but does not list specific numeric standards for any of the indicator chemicals at the Site. The Basin Plan's toxicity objective is as follows:

All waters shall be maintained free of toxic substances in concentrations that are lethal to or that produce other detrimental responses in aquatic organisms. Detrimental responses include, but are not limited to, decreased growth rate and decreased reproductive success of resident or indicator species and/or significant alterations in population or community ecology or receiving water biota.

In addition to the above water-quality objective, EPA has defined ambient water-quality criteria for specific chemicals, including several of the indicator chemicals at the Site. The EPA water-quality criteria for protection of salt water aquatic life are potential ARARs to protect aquatic life in the Lauritzen Canal. The criteria for the indicator chemicals are expressed as chronic levels (24-hour averages) and acute levels (maximum concentrations). Those criteria are listed in Table 2-2.

2.2.2.3 Ground Water

The chemical-specific requirements identified for this medium would only be ARARs if the ground water at the Site were considered to be an existing or potential source of drinking water. The ground water at the Site does not currently serve as a drinking water source, and no water supply wells have been installed at or near the facility.

Further, California and EPA guidelines, definitions, and policies specify a maximum total dissolved solids (TDS) concentration of 3,000 ppm to 10,000 ppm for underground sources (or potential sources) of drinking water (H.S.C 25208.2; SWRCB Resolution 88-63; 40 CFR 146.3). As discussed in Section 5.1.4 of the RI Report, the TDS concentration of ground water at the Site is approximately 14,000 ppm. Based on the TDS concentration value, ground water at the Site is not considered to be a potential source of drinking water. Although no chemical-specific ARARs have been identified for this medium, the State of California's Non-Degradation Policy is a TBC criterion for establishing remedial action objectives for ground water (see Section 2.2.5).

2.2.2.4 Air

The available air monitoring results for the Site have detected generally low airborne pesticide concentrations at on-site and off-site locations. According to a preliminary screening calculation in the PHE, the potential excess lifetime carcinogenic health risk to downwind receptors due to DDT emissions from the Site would be approximately $10^{-7}$. This excess cancer risk is less than the range of $10^{-4}$ to $10^{-6}$, which EPA generally considers to be acceptable risk levels for Superfund cleanups [40 CFR 300.430 (e)(2)(i)(A)(2) and FR vol. 55, p. 8716]. Therefore, the release of indicator chemicals to ambient air at the Site has not been identified as a pathway with significant health risks to residents living downwind of the Site.

There are no National Ambient Air Quality Standards (NAAQS) or National Emission Standards for Hazardous Air Pollutants (NESHAPS) for the indicator chemicals at this Site.

Chemical-specific ARARs have been identified for the protection of workers involved in future cleanup activities at the Site. Regulations adopted by OSHA, under provisions of the Occupational Safety and Health Act (29 U.S.C. Sections 651-678) specify permissible exposure limits (PELs) for worker safety. These PELs will be considered in the development of a health and safety plan for remediation of the Site.

#### 2.2.2.5 Seafood

The San Francisco Bay Conservation and Development Commission (BCDC) has zoned the Lauritzen Canal as Port Priority Use - Water Related Industry. Given the industrial development and use of the Lauritzen Canal, virtually no commercial or recreational fishing occurs in this water body. Therefore, the ingestion of seafood contaminated with the indicator chemicals is not believed to constitute a significant human exposure pathway at the Site, and no chemical-specific ARARs have been identified. However, several TBC criteria have been evaluated, as discussed in Section 2.2.5 of this report.

### 2.2.3 ACTION-SPECIFIC ARARS

Action-specific ARARs are State or federal requirements which may be triggered by the type of remedial action undertaken at the Site. For example, possible remedial actions may include the treatment and/or disposal of pesticide-affected soils from the Site, or the dredging and disposal of sediments from the Lauritzen Canal. ARARs pertaining to these remedial actions are generally technology-based procedures, standards, or concentration limits. Possible action-specific ARARs are highlighted in this section and reviewed in greater detail in Section 4.2 (Detailed Analyses of Alternatives).

2.2.3.1 Remediation of Soils

The RCRA, as amended by the HSWA, defines a number of federal requirements which might be triggered by remediation of soils containing RCRA wastes at the Site.

For purposes of determining ARARs under RCRA, most of the soils containing the indicator chemicals are considered to be RCRA wastes. The soils which contain a total concentration of the indicator chemicals (halogenated organic compounds or HOCs) greater than 1,000 mg/kg are considered to contain California list wastes. Soils which contain less than 1,000 mg/kg of HOCs are considered to contain various P and U list wastes.

The distinction is important in relation to the RCRA land disposal restrictions (LDRs) which are described in 40 CFR 268. Soils from this site which contain the California list wastes described above are prohibited from land disposal (without treatment) after November 8, 1990. The required RCRA treatment standard is incineration in an incinerator, boiler, or industrial furnace.

Effective May 8, 1990, treatment standards based on incineration were adopted for RCRA wastes containing the individual indicator chemicals (P and U listed wastes). Due to insufficient incinerator capacity, soils and debris containing these chemicals were granted a national capacity variance which allows disposal without treatment until May 8, 1992. Therefore, soils which contain less than 1,000 mg/kg of the indicator chemicals are prohibited from land disposal after May 8, 1992 without treatment unless the hazardous constituents are present at concentrations less than the treatment standard. The performance level treatment standards are shown in Table 2-3 and apply to RCRA wastes.

The LDRs are triggered by land disposal, which is defined as placement into a land disposal unit. Placement does not occur when waste is left in place, treated in situ, or consolidated within a unit. If placement does not occur, the LDR requirements are not triggered. Further, EPA generally equates the CERCLA area of contamination with a single RCRA land-based unit (FR vol. 55, pp. 8759-8760). Therefore, consolidation of RCRA wastes within a CERCLA area of contamination would not be placement and the LDRs would not be triggered and would not be ARARs.

If placement of a RCRA waste occurs, LDRs could be applicable. However, as discussed in the preamble to the National Contingency Plan (FR vol. 55, p. 8760), EPA has concluded that until specific standards for soil and debris are developed, current Best Demonstrated Available Technology (BDAT) standards are generally inappropriate for CERCLA response actions. EPA presumes that because contaminated soil and debris are significantly different from the wastes evaluated in establishing the treatment standards, the soil would qualify for a treatability variance under 40 CFR 268.44. The variance, if necessary, would then be included in the Record of Decision (FR vol. 55, pp. 8760-8761).

EPA has promulgated regulations under 40 CFR 264 for permitted hazardous waste disposal facilities. DHS has promulgated regulations under CCR Title 22, Article 29 for landfills. Portions of these regulations would be ARARs for the disposal of soils which are RCRA hazardous wastes. Details of these ARARs are discussed in Section 4.2 (Detailed Analysis of Alternatives).

#### <u>2.2.3.2 Remediation of Offshore Sediments from Lauritzen Canal</u>

As discussed in Section 2.2.2.1, the sediments from the Lauritzen Canal are not considered to be RCRA wastes. However, these sediments would be hazardous wastes under California law if they contain indicator chemicals at concentrations that exceed the TTLC or STLC levels. The DHS non-RCRA LDRs described below may be applicable for those sediments determined to be hazardous under the State criteria.

The DHS has implemented generic land disposal treatment standards for non-RCRA hazardous waste. The sediments affected with the indicator chemicals are regulated under the generic category of solids with organics; the treatment standard for this category of non-RCRA wastes went into effect on May 8, 1990, and established a disposal prohibition date of May 8, 1992 (DHS, 1990). The two-year delay in the prohibition date is due to the lack of incineration and solvent extraction treatment capacity.

Further, solid non-RCRA hazardous waste generated in the cleanup of any hazardous waste site is categorically exempt from the LDRs if the disposal of such waste is approved by the DHS (Health and Safety Code Section 25179.6(a)(2)). To approve the disposal, the Department is required to consider the factors listed in Health and Safety Code Section 25356.1 for approval of remedial action plans outlined in the National

Contingency Plan plus six factors established by the State. The remedial action which will be approved for this site will be selected based on the factors listed in Section 25356.1; therefore, it is expected that the non-RCRA hazardous waste sediments would qualify for the exemption.

DHS requirements for treatment and disposal may be ARARs for remediation of the sediments. These requirements are discussed in the Section 4.2 (Detailed Analysis of Alternatives).

Additionally, dredge and fill activities which may be implemented at the Site would be regulated under several State and federal laws, as noted below.

McAteer-Petris Act and the San Francisco Bay Plan

The BCDC issues permits for the placement of fill in San Francisco Bay (up to the line of highest tidal action), public access along a 100-foot shoreline band adjacent to the Bay, and dredging and dredged material disposal in the Bay. Approvable projects must be consistent with stringent agency policies contained in the McAteer-Petris Act and the San Francisco Bay Plan.

In general, BCDC fill policies allow the minimum necessary bay fill only for water-oriented uses, and only if no alternative upland location for the project exists. However, Government Code Section 66632(f) provides that BCDC will grant a permit if it finds and declares that the proposed fill activity is "necessary to the health, safety, or welfare of the public in the entire bay area." Therefore, fill placed for purposes other than water-oriented uses could be approved under the above circumstances.

BCDC dredging policies focus on locations for dredged material disposal and physical and chemical water-quality impacts during dredging and disposal operations. BCDC policies also require appropriate mitigation for bay fill, seismic safety of fills, and protection of bay resources during dredging and filling operations including water quality, fish and wildlife, water surface area and volume, commercial fishing, recreation, and public access. BCDC will refer to or coordinate with other agencies such as the Regional Water Quality Control Board (RWQCB) for water-quality protection issues or the California Department of Fish and Game (CDFG) for habitat protection issues.

BCDC would be expected to provide input for remedial activities involving the Lauritzen Canal and shoreline band, including dredging operations, removal and reconstruction of the wharf, and fill placement. BCDC statutes and regulations are applicable under CERCLA because the proposed work is both within the agency's jurisdiction and within the scope of its regulatory activities. However, BCDC policies would not be ARARs but are TCB criteria.

<u>Section 10 of the Rivers and Harbors Act</u>
This federal statute prohibits the unauthorized obstruction or alteration of any navigable water of the United States. Navigable waters of the United States are defined as waters that are subject to the ebb and flow of the tide shoreward to the mean highwater mark and/or are presently used, or have been used in the past or may be used to transport interstate or foreign commerce. The Lauritzen Canal would fall under this definition. Section 10 regulates structures or work in, above, or under navigable waters. Examples of regulated activities would include dredging, filling, installation of pilings, and construction of dams and piers. The U.S. Army Corps of Engineers is responsible for reviewing and approving applications for permits to conduct the above activities.

<u>Section 404 of the Clean Water Act</u>
This federal statute regulates the discharge of dredged or fill materials to all waters of the United States, including wetlands. While proposed dredging activities in the Lauritzen Canal would not be regulated under Section 404, the placement of dredged or fill materials in the Lauritzen Canal would be regulated under this statute and the related regulations promulgated in 40 CFR 230.10. As with Section 10 of the Rivers and Harbors Act, the U.S. Army Corps of Engineers is responsible for reviewing and approving applications for permits to discharge dredged or fill materials. EPA also reviews Section 404 permit applications for compliance with Section 404 and other provisions of the Clean Water Act. Under CERCLA Section 121(e), a Section 404 permit would not be required for dredge and fill activities conducted on site. However, substantive requirements of the Section 404 regulations may be enforced by the lead agency.

A guiding principle of the Section 404 regulations is that degradation or destruction of wetlands and other special aquatic sites should be avoided to the extent possible. However, EPA has developed the following guidelines for CERCLA response actions involving wetlands that have already been severely degraded by virtue of prior discharges of waste (EPA, 1988b):

> While part of the CERCLA remedy may be to fill in the wetland, the remedy would contemplate that the fill will serve an environmental benefit. Where the functioning of the wetland has already been significantly and irreparably degraded, mitigation would be oriented towards minimizing further adverse environmental impacts, rather than attempting to recreate the wetland's original value on-site or off-site.

In other words, EPA's guidance specifies that the remedial action plan may include filling of a wetland area if there are no practicable alternatives and the resulting fill would provide an environmental benefit.

Section 103 of the Marine Protection Research and Sanctuaries Act (MPRSA)

This federal law regulates ocean discharges of materials dredged from waters of the United States. Jurisdictional limits under Section 103 extend seaward from the low tide line where the shore directly contacts the open sea. Therefore, Section 103 would not apply to dredging or fill activities performed within the Lauritzen Canal. Section 103 also requires that permits be issued to transport dredged materials to be dumped into ocean waters, and that such materials be dumped only at sites which have been designated by EPA under Section 102 of the MPRSA. The U.S. Army Corps of Engineers is responsible for issuing ocean dumping permits for dredged materials under Section 103 of the MPRSA. In addition, EPA reviews Section 103 permits for compliance with other applicable provisions of the MPRSA. It would be necessary to obtain an ocean dumping permit from the U.S. Army Corps of Engineers for any proposed ocean disposal of sediments dredged from the Lauritzen Canal.

2.2.3.3 Discharge of Pollutants to Surface Water

The substantive requirements of a National Pollutant Discharge Elimination System (NPDES) permit are applicable to point source discharges such as those from a treatment system with an outfall to surface waters. The RWQCB issues waste discharge requirements (WDRs) where discharged waste could affect the quality of waters of the State. The WDRs typically include effluent discharge limitations and monitoring requirements based on Water Quality Standards set forth in the RWQCB's Basin Plan.

#### 2.2.3.4 Federal and State Worker Protection Requirements

Regulations for some of the chemicals of concern at the Site have been promulgated to protect workers. These standards may apply to workers participating in remedial actions undertaken at the Site. A site-specific Health and Safety Plan will be developed and implemented to comply with the appropriate federal (found at 29 CFR 1910) and State (found at Title 8 CCR) Occupational Safety and Health Standards.

### 2.2.4 LOCATION-SPECIFIC ARARS

Location-specific ARARs are restrictions which are considered solely because of specific setting characteristics. Potential location-specific ARARs, such as requirements found in 40 CFR 264.18 (a) and (b) regarding citing of hazardous waste facilities, the Endangered Species Act, the Executive Order on Protection of Wetlands, and the Archaeological and Historic Preservation Act, were considered. However, given the site setting described below, no location-specific ARARs were identified for the Site.

As stated in Section 2.5 of the RI Report, no critical habitats or rare, threatened, or endangered species have been identified at or in the immediate vicinity of the Site. The current site topography was created by dredging, filling, and grading intertidal marshland. The Upland Area of the Site consists generally of sandy gravel fill overlying Bay Mud. Based on the conditions prior to industrial development, and the extensive bay filling activities that have taken place over time, the Site is not expected to be of cultural significance.

The Site is located in an area which the National Flood Insurance Administration has classified as Zone C (areas of minimal flooding) (National Flood Insurance Administration, 1979). Since the Site is not located in a 100-year flood plain, the federal and State requirements for hazardous waste treatment, storage, or disposal facilities located in a 100-year flood plain would not be ARARs for the Site.

The Hayward Fault, located approximately 3 miles from the Site, is the closest fault which has experienced displacement during Holocene time (California Division of Mines and Geology, 1982). This distance is substantially greater than the 200-foot minimum distance which the federal and State regulations specify for the citing of new facilities for the treatment, storage, or disposal of hazardous wastes.

### 2.2.5 TO BE CONSIDERED (TBC) FACTORS

In evaluating remedial alternatives and their potential future level of remediation, various criteria, resolutions, or guidelines may be considered in the FS. These "to-be-considered" criteria (TBCs) are not ARARs. The following discussion presents selected criteria considered in the development of remedial alternatives.

#### 2.2.5.1 DHS-Recommended Soil Cleanup Levels

The DHS established guidelines for developing recommended soil cleanup levels (RSCLs) are in the California Site Mitigation Decision Tree Manual, May 1986 (DHS, 1986). The RSCLs are established on a site-specific basis and are dependent on data available for each compound at the site. Generally the RSCL is equal to the drinking water standard times a factor of 100 for attenuation of this compound by the soil and a factor of 10 for dilution by ground water. These guidelines are related to protecting ground water for drinking water purposes. Since the ground water at the Site is not a source or a potential source of drinking water, these RSCLs are not considered further.

#### 2.2.5.2 California Resolution 68-16

California's "Statement of Policy with Respect to Maintaining High Quality of Waters in California," Resolution 68-16, requires maintenance of existing water quality unless it is demonstrated that a change will benefit the people of the State, will not unreasonably affect present or potential uses, and will not result in water quality less than prescribed by other State policies. Further, the resolution requires that any activity which discharges waste to high quality waters be required to meet waste discharge requirements which result in treatment or control of the discharge to ensure that pollution or nuisance will not occur and that the highest water quality consistent with maximum benefit to the people of the State be maintained. Resolution 68-16 is "not a 'zero discharge' standard but rather a policy statement that existing quality be maintained when it is reasonable to do so." (I.B.M., State Water Resources Control Board Order No. WQ 86-8). This resolution does not meet the definition of an ARAR but is included as a criterion to be considered.

### 2.2.5.3 Pesticide Residues in Food

Under the authority of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), EPA establishes tolerances for pesticides in food. Of the chemicals of concern, tolerances for residues of endrin and lindane have been established. Those tolerances are related to residues on agricultural commodities which do not include fish or shellfish; therefore, the tolerances are neither ARARs or TBC criteria.

The FDA has established action levels and tolerances which represent limits at or above which the FDA will take legal action to remove adulterated products, including shellfish from the market. These levels apply to the commercial sale of seafood and are not considered to be regulatory levels for such activities as sport fishing, crabbing or non-commercial shellfish harvesting. These levels are not ARARs or TBC criteria, given the fact that virtually no commercial or recreational fishing occurs in the Lauritzen Canal.

The EPA establishes ambient water quality criteria to protect human health through consumption of aquatic organisms. However, since the exposure assumptions reflected in EPA's water quality criteria are not consistent with the designated use of the Lauritzen Canal as a marine shipping channel for water-related industry, these criteria would not be ARARs or TBC criteria for the Site.

### 2.2.5.4 Proposition 65

The Safe Drinking Water and Toxic Enforcement Act of 1986 is commonly known as Proposition 65. It prohibits knowingly or intentionally exposing any individual to a chemical known to cause cancer or reproductive toxicity without giving clear warning unless there is no significant risk due to the exposure. No significant risk is defined under Proposition 65 as a risk less than $10^{-5}$. Proposition 65 also prohibits knowingly releasing Proposition 65 chemicals to drinking water. With the exception of endrin, the indicator chemicals are Proposition 65 listed chemicals. The Proposition 65 requirements are not ARARs or TBC criteria, as water which could be impacted by the Site is not drinking water and the air sampling results indicate a risk level associated with a $10^{-7}$ (i.e., significantly below the no significant risk level of Proposition 65).

#### 2.2.5.5 California Environmental Quality Act

The California Environmental Quality Act (CEQA), codified in Title 14, California Code of Regulations, Division 6, provides for the environmental review of projects. The California Resources Agency administers CEQA, and requires that environmental impact reports, similar to federal environmental impact statements, be conducted for projects which may have significant environmental effects. Since the CEQA process was not intended for use with Superfund cleanup activities, CEQA would not be an ARAR for the Site. However, DHS has occasionally required completion of an EIR, or has issued a Negative Declaration for proposed remedial activities at Superfund sites. Therefore, CEQA has been identified as a TBC criterion. In some cases, the Resources Agency has used the remedial investigation and feasibility study reports to meet the substantive requirements of CEQA.

## 2.3 Remedial Action Objectives

Remedial action objectives for upland soils, embankment sediments, and offshore sediments at the Site have been developed based on the RI data, the PHE findings, and a review of ARARs. Controlling the potential migration of contaminants from the above media will ensure that indicator chemical concentrations in ambient air, surface water, and ground water remain at levels which are protective of human health and the environment.

Where appropriate, separate remedial action objectives have been developed for protection of human health and the environment. The remedial action objectives and cleanup goals described below have been used to develop the range of remedial alternatives presented in Section 4.0 of this FS Report. Table 2-4 summarizes the proposed cleanup goals for the Site.

### 2.3.1 UPLAND SOILS

The remedial action objectives for protecting human health are to prevent direct contact with chemical-affected soils; and to prevent the erosion of these soils to the air pathway. The remedial action objective for environmental protection is to limit the potential migration of indicator chemicals from upland soils to surface water and ground water.

The remedial alternatives presented in Section 4 include on-site containment and/or off-site treatment and disposal options to meet the above objectives. Upland areas with indicator chemical concentrations greater than 1 ppm are targeted for remediation.

### 2.3.2 EMBANKMENT SEDIMENTS

The remedial action objective for protecting human health is to prevent direct contact with the chemical-affected shoreline sediments. The remedial action objective for environmental protection is to significantly reduce erosion of these sediments and the potential exposure of estuarine organisms to these sediments. Embankment sediments with indicator chemical concentrations greater than 1 ppm are targeted for remediation.

### 2.3.3 OFFSHORE SEDIMENTS IN LAURITZEN CANAL

The occurrence of indicator chemicals in offshore sediments is not believed to present a significant threat to human health, based on current restrictions on commercial and sport fishing in the Lauritzen Canal. Therefore, no cleanup goals have been specifically proposed for the protection of human health.

The remedial action objective for environmental protection is to clean up offshore sediments which contain indicator chemicals at concentrations greater than regional background levels. The removal and/or containment of these sediments would significantly reduce the potential for estuarine species to be exposed to indicator chemicals from the Site.

Lauritzen Canal sediments with total DDT concentrations greater than 0.2 ppm are targeted for remediation. This value represents the average total DDT concentration which has been reported for all peripheral waterways to San Francisco Bay, exclusive of the Lauritzen Canal (see Section 5.2 of the RI Report).

The cleanup goal for Lauritzen Canal sediments has been defined in terms of total DDT because an extensive regional database already exists for this pesticide; DDT has been detected over a more widespread area than the other indicator chemicals; and DDT has generally been detected at higher concentrations than other compounds.

# 3.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

## 3.1 General Response Actions and Technology Types

General response actions describe the basic approaches (e.g., removal, containment, or treatment) which possibly could be used to satisfy the remedial action objectives for upland soils, embankment sediments, and offshore sediments at the Site. One or more remedial technologies are associated with each general response action. These remedial technologies represent general categories, such as soil excavation, physical treatment, or off-site disposal. At this point in the FS process, the remedial technologies are evaluated on the basis of their technical implementability. Those technologies which are not technically implementable are screened from further consideration.

Tables 3-1, 3-2, and 3-3 present the general response actions and remedial technologies which have been identified for upland soils, embankment sediments, and offshore sediments at the Site. These actions include "no action," as required under CERCLA, and various removal, containment, treatment, and disposal actions. As discussed below, with the exception of biological treatment, all of these general response actions and remedial technologies are potentially applicable for the Site, and have therefore been retained for further evaluation.

### 3.1.1 GENERAL RESPONSE ACTION: "NO ACTION"

CERCLA requires including the "no action" alternative as a baseline to compare other alternatives. If the "no action" alternative were selected, no activities would be undertaken to remediate environmental contamination at the site. However, institutional actions, as described below, might be implemented as part of the "no action" alternative to protect human health and monitor site conditions.

### 3.1.2 GENERAL RESPONSE ACTION: INSTITUTIONAL ACTIONS

Institutional actions could be implemented to reduce the potential for human exposure to chemicals of concern at the site. For example, access control measures such as fencing, signs, and security personnel could be used to prevent unauthorized access to the Site. Land-use restrictions could be implemented by means of deed restrictions.

Additionally, various environmental media (e.g., air, ground water, marine organisms, and offshore sediments) could be monitored periodically to evaluate future compound concentrations, mobility, and the potential for future human exposures or environmental effects.

### 3.1.3 GENERAL RESPONSE ACTION: REMOVAL

The removal response consists of transferring the more highly contaminated soils, embankment sediments, and offshore sediments at the Site to other on-site or off-site locations, where they could then be treated or disposed using other remedial technologies.

General types of removal technologies include the excavation of shallow upland and embankment sediments, and the dredging of offshore sediments from the Lauritzen Canal. Removed soils and sediments would require further response actions, such as treatment, on-site containment, or disposal at an approved site, to reduce the volume, concentrations, or mobility of the affected materials,

### 3.1.4 GENERAL RESPONSE ACTION: CONTAINMENT

The containment response action includes capping the Upland Area, stabilizing the shoreline, and encapsulating offshore sediments to reduce or eliminate the mobility of chemical-affected soils and sediments. Horizontal barriers (e.g., asphalt cap) would control erosion, significantly reducing the potential for transport of contaminated upland soils to air and surface water. Although ground-water contamination has not been identified as a significant problem at the Site, paving the Upland Area would reduce or eliminate the percolation of surface water through chemical-affected vadose-zone soils, further reducing the potential for soil contaminants to be transported into ground water.

Shoreline stabilization measures would significantly reduce or eliminate the potential for erosion of chemical-affected embankment sediments to the Lauritzen Canal. Possible shoreline stabilization technologies include revetments, seawalls, and bulkheads.

Chemical-affected offshore sediments could be contained by encapsulation within the Lauritzen Canal or at an upland disposal site. This technology would prevent marine organisms from becoming exposed to sediments which contain DDT and other chemicals of concern.

### 3.1.5 GENERAL RESPONSE ACTION: TREATMENT

Treatment technologies would potentially reduce volume, toxicity and/or mobility of the affected materials. Possible treatment technology types for soil and/or sediments include:

- physical treatment to immobilize chemicals within or remove them from affected soil and sediments.
- biological treatment of chemical-affected soils and sediments to reduce their toxicity or volume.
- chemical treatment to transform chemicals of concern into less toxic substances.
- thermal treatment of contaminated soils and sediments by incineration or vitrification.

With the exception of biological treatment, all of the above remedial technologies have been retained for further evaluation. As reviewed in Section 4.1 of the RI Report, the chlorinated pesticides at the Site are resistant to biodegradation. For example, DDT has a reported half-life in soils of approximately 10 years. The two main degradation products of DDT are DDD and DDE. These compounds, and the other indicator chemicals at the Site (i.e., aldrin, dieldrin, and endrin), have similarly long half-lives. No microbial treatment technologies have been developed which would effectively degrade these substances. Therefore, since biological treatment is not technically feasible, it has been eliminated from further consideration in this FS Report.

### 3.1.6 GENERAL RESPONSE ACTION: DISPOSAL

The disposal response consists of transferring chemical-affected soils and sediments to an approved off-site land disposal facility. These soils and sediments might require treatment prior to disposal to meet ARARs. However, EPA has recognized that engineering controls to reduce contaminant mobility would be appropriate when treatment is not practical, or when the wastes pose a relatively low long-term risk to human health or the environment.

## 3.2 Process Option Screening Criteria

This section of the FS Report describes and evaluates various process options for each of the remedial technologies which were identified in the previous section as being potentially applicable for the Site. The term "process options" refers to specific processes within each type of remedial technology. For example, the physical treatment remedial technology includes soil extraction and fixation as process options. Tables 3-4, 3-5, and 3-6 list the process options which have been identified for upland soils, embankment sediments, and Lauritzen Canal benthic sediments, respectively.

In accordance with EPA's RI/FS Guidance Document and the NCP, each of the process options listed in Tables 3-4, 3-5, and 3-6 has been evaluated on the basis of its effectiveness, implementability, and cost. Process options which are not effective, implementable, or cost effective are screened from further consideration at this point in the FS process.

Where possible, one representative process option has been selected for each technology type to simplify the subsequent development and evaluation of alternatives without limiting flexibility during remedial design. In some cases, more than one process option has been selected for a technology type. This has been done when two or more process options are sufficiently different in their performance that one does not adequately represent the other.

The criteria of effectiveness, implementability, and cost are described below, followed by the screening evaluations completed for each process option. Tables 3-7, 3-8, and 3-9 summarize this process for upland soils, embankment sediments, and Lauritzen Canal offshore sediments, respectively.

<u>Effectiveness</u>
This criterion focuses on the potential effectiveness of the process option to handle the estimated areas or volumes of media necessary to satisfy the remedial action objectives; the potential impacts to human health and the environment during implementation and any construction phase; and the reliability and proven history of the process option with respect to the chemicals and conditions found at the Site. Where several process options have been identified for a given remedial technology, the effectiveness of each process option has been evaluated relative to other processes within the same general technology type.

<u>Implementability</u>
Implementability encompasses both the technical and institutional feasibility of carrying out each process option, including obtaining necessary permits, the availability of treatment, storage and disposal services (including capacity), and the availability of equipment and skilled workers to implement the particular process.

Cost
Cost plays a limited role in the screening of process options, with relative capital and operation and maintenance costs being used rather than detailed estimates. At this stage, the cost analysis is primarily based on engineering judgment, with process option costs being estimated as high, low, or moderate. Where more than one process option is identified for a given technology, costs are estimated relative to other process options in the same general technology type. If more costly process options within a particular technology type yield no significant advantages or are less advantageous, then these options are eliminated from further consideration.

## 3.3 Remedial Technologies and Process Options for Upland Soils

### 3.3.1 REMEDIAL TECHNOLOGY: "NO ACTION"

#### 3.3.1.1 Process Option: "No Action"

The "no action" alternative serves as a baseline to compare with other remedial alternatives and is required to be considered under CERCLA and the NCP. With this technology, no remedial technologies would be implemented. However, various institutional actions and periodic environmental monitoring would be incorporated into the "no action" alternative.

Effectiveness
Since no further remedial activities would be undertaken, there would be virtually no reduction in the toxicity, mobility, or volume of chemicals at the Site. As previously noted in this FS Report, the human health risks associated with the upland soils involve the potential exposure of downwind area residents to airborne dust which may contain low concentrations of chlorinated pesticides. The "no action" process option would not reduce the risks associated with these potential exposures.

Implementability
The "no action" process option is implementable.

Cost
The "no action" process option has a very low cost in comparison to other process options.

Overall Evaluation
As required by CERCLA and the NCP, the "no action" alternative has been retained for further consideration.

3.3.2 REMEDIAL TECHNOLOGY: LAND-USE RESTRICTIONS

3.3.2.1 Process Option: Deed Restrictions

Deed restrictions could be applied to chemical-affected areas to limit future exposures to upland soils at the Site. Such restrictions could identify the specific areas where hazardous wastes are located, and require that appropriate safeguards be undertaken to prevent exposure to contaminants during future excavation or development of the Site. Additionally, deed restrictions could be filed to ensure that future site uses are consistent with the Site's current municipal zoning classification for heavy industrial activities (M-3).

Effectiveness
Deed restrictions would protect human health by reducing future exposures to affected soils and prohibiting future development of the Site for such uses as residential housing, schools, or hospitals.

Implementability
Deed restrictions would be implementable.

Cost
Deed restrictions would probably be relatively inexpensive to implement. However, the property value of the Site might be lowered by the existence of deed restrictions which limit future site use or development. The resulting devaluation of the Site, if any, is not known.

Overall Evaluation
Deed restrictions would be effective, implementable, and relatively low in cost to implement. Therefore, this process option has been retained for consideration in the development of remedial alternatives for the Site.

3.3.3 REMEDIAL TECHNOLOGY: SITE ACCESS RESTRICTIONS

3.3.3.1 Process Option: Access Control Measures

This process option consists of establishing barriers and other security measures to reduce general access to the Upland Area. Typical security measures include fencing (e.g., chain-link and/or barbed wire), walls, warning signs, and security guards.

Since the Upland Area is currently fenced and posted with warning signs, and LRTC personnel are present on a 24-hour basis, this process option has already been implemented. Site access is controlled with a 6-foot-high chain-link fence which is topped with barbed wire. The Upland Area adjacent to the Lauritzen Canal has not been fenced, but is relatively inaccessible from the water due to the presence of a pile-supported dock built over most of this area. Vertical sheet pile walls (approximately 10 feet high) installed along the northern section of the embankment further restrict access to the Upland Area. The presence of LRTC personnel at the Site, on a 24-hour basis, significantly discourages unauthorized access to the Site.

Effectiveness
The security measures already in place are believed to effectively restrict access to the Site. Therefore, further access restrictions in the Upland Area are believed to be unnecessary to protect human health.

Implementability
Site access restrictions have already been implemented, as noted above.

Cost
Maintaining the existing access barriers would be relatively inexpensive.

Overall Evaluation
Access control measures are already in place and will be retained for further consideration as a process option.

### 3.3.4 REMEDIAL TECHNOLOGY: ENVIRONMENTAL MONITORING

#### 3.3.4.1 Process Options: Visual Inspections and Chemical Analyses

Environmental monitoring could be used to evaluate future conditions in the Upland Area under the "no action" alternative, and the long-term effectiveness of implemented remedial measures. Monitoring might also be necessary to confirm that short-term potential exposures remain at acceptably low levels during cleanup activities (e.g., soil removal).

The particular environmental monitoring activities performed would depend on the remedial alternative selected for the Site. The most comprehensive long-term monitoring would probably be performed under the "no action" alternative, since no chemical-affected soils would be removed from the Site and the potential human and environmental exposure risks would remain unchanged. Less monitoring would be necessary for those alternatives which include containment, treatment or removal of contaminated media from the Site.

The specific types of monitoring which could be conducted at the Upland Area include visual inspections, and chemical analyses of air and ground-water samples. These monitoring options are described below.

Visual Inspections
This type of monitoring could be used to evaluate site conditions under the "no action" alternative, and the performance of various remedial alternatives. For example, the Upland Area could be monitored for erosional features (e.g., rills, gullies). Caps, engineered drainage controls, or other structures built at the Site could also be visually monitored for signs of deterioration.

Air Sampling
Although ambient air monitoring has not indicated a significant human health risk to downwind receptors, it may be appropriate to perform periodic air monitoring under the "no action" alternative to confirm earlier sampling results.

Short-term air monitoring might be implemented during site cleanup activities (e.g., soil excavation). However, long-term air monitoring would be unnecessary for remedial alternatives which include paving upland areas, since this remedial component would be expected to virtually eliminate fugitive dust from chemical-affected soils at the Site.

Ground-Water Sampling
Ground-water monitoring could be conducted periodically to monitor chemical concentrations and ground-water levels. This activity would be an appropriate component for all remedial alternatives, including the "no action" alternative. Future ground-water quality data would be used to confirm existing data which indicates very low concentrations of indicator chemicals in ground water at the Site.

The effectiveness, implementability, and cost of the above environmental monitoring activities are discussed below.

Effectiveness
Environmental monitoring process options would not reduce the risks associated with potential exposures; however, they would help to assess the magnitude of exposures, chemical mobility and attenuation, and remedial effectiveness.

Implementability

Monitoring would be a readily implementable option for the Site. All media samples for laboratory analyses would be collected using appropriate protocols and submitted to a State-certified analytical laboratory for analysis. The specific monitoring program developed would depend on the remedial alternative selected for the Site.

Cost

The costs of environmental monitoring process options would be highly dependent on the type, frequency, and length of time such monitoring would be required. For relatively short monitoring periods (such as during soil excavation), costs would be low to moderate. For long-term monitoring, the costs would be relatively high.

Overall Evaluation

Environmental monitoring has been retained to evaluate future conditions at the Upland Area of the Site. The specific monitoring options selected will depend on the scope of each remedial alternative, but could include visual inspections, chemical analyses of air samples, and chemical analyses of ground-water samples.

### 3.3.5 REMEDIAL TECHNOLOGY: EXCAVATION OF UPLAND SOILS

#### 3.3.5.1 Process Option: Excavate Soils

This option would consist of removing soils from selected areas using a backhoe or other conventional earth moving equipment. After excavation, soils would need to be contained, treated or disposed of using other remedial technologies.

Effectiveness

Excavation of highly contaminated soils from selected areas could effectively reduce the potential mobility of indicator chemicals at the Site. Dust suppression and emissions monitoring might be required during excavation to reduce potential health risks to remedial contractors and facility personnel.

Implementability

The implementability of this option would depend on the extent and location of soils proposed for excavation. Removal of source area soils could be accomplished with conventional excavation equipment. However, excavation activities could be significantly complicated by the presence of existing structures in the Upland Area, including underground utilities, buildings, and the train scale. These structures might require shoring and/or dismantling as part of the excavation. Soil excavation and related activities would be timed with facility operations to minimize the amount of time that facility operations would be disrupted.

Cost
The cost of excavating selected soils would depend largely upon the location and extent of material to be excavated. Costs could be significantly increased by the presence of existing structures and the disruption of normal operations at LRTC's facility. The costs for treatment and/or disposal of excavated soils would be very high, as discussed below.

Overall Evaluation
Excavation will be retained for consideration for selected source area soils from the Upland Area.

### 3.3.6 REMEDIAL TECHNOLOGY: HORIZONTAL BARRIERS

#### 3.3.6.1 Process Options: Modify Drainage, Grade, or Seal Surface

Upland soils containing chlorinated pesticides could be graded and sealed with a variety of materials, including asphalt, concrete, low permeability soils or clays, synthetic membranes, or geotextile fabrics. A multimedia cap could be designed using a combination of the above materials. Drainage piping could be installed to channel precipitation and runoff from the Site.

Effectiveness
Capping would virtually eliminate the wind erosion of contaminated surface soil and fill material. Although ground water has not been significantly impacted by indicator chemicals at the Site, the installation of a cap would significantly reduce or eliminate the infiltration of surface water to ground water, further reducing the potential for ground-water contamination.

Implementability
Modification of drainage, capping of source area soils, and the construction of a lined containment area are implementable at the Site. However, the existing railroad lines, pile-supported wharf, and other structures would limit the extent to which elevations could be changed at the Site. The choice of capping material would need to be compatible with LRTC's existing facility operations. For example, if

horizontal barriers were constructed at portions of the Site which are used for bulk material storage, the capped surface and/or subsurface liners would need to withstand heavy equipment loads and be able to support the weight of stockpiled products.

Cost
The costs for horizontal barriers would be moderate compared with other remedial technologies. However, if existing rail lines or other major structures would have to be altered as part of a grading/capping plan, then costs could be much higher.

Overall Evaluation
Grading, capping, subsurface liners, and drainage controls will be retained as process options for the Site.

3.3.7 REMEDIAL TECHNOLOGY: PHYSICAL TREATMENT

3.3.7.1 Process Option: Soil Extraction

This process option would remove the chlorinated pesticides from upland area soils using a liquid extractant (e.g., organic solvents or surfactant solutions). The process typically involves mixing the affected soil with the extractant in a tank. After the specified mixing time, the solids would be removed from the extractant by centrifugation or another separation method. The solids would be extracted a second or third time with a clean extractant solution, if necessary, to adequately remove pesticide residues. The extracted soils would then be washed to remove the extractant, followed by a drying step, prior to final disposal.

After being mixed with the contaminated soil matrix, the extractant would be separated and further processed to concentrate the dissolved pesticide wastes. The extractant would be evaporated or otherwise concentrated to reduce the amount of liquid waste requiring treatment and final disposal as a hazardous waste.

Effectiveness
While the soil extraction process is theoretically possible, it has not been demonstrated to be an effective process option for the chlorinated pesticides identified as indicator chemicals at the Site. As discussed in Section 4.0 of the RI Report, DDT and the other chlorinated pesticides have very high sorption coefficients for soils. Therefore, to effectively remove these compounds from affected soils, it would be necessary to use an aggressive organic extractant and

a series of rigorous mixing processes to break up clumps of soil into fine-grained sediments. Bench- and pilot-scale treatability studies would need to be performed to further evaluate the effectiveness of this process option. The solid/liquid separation process could be difficult to perform due to the high percentage of silt- and clay-sized sediments in the affected soils. Another problem with the process is the creation of a liquid solvent/pesticide waste stream. Moreover, organic extractant residues remaining on the treated soils could create the potential for soil and ground-water contamination if these soils were disposed on site.

Implementability

There are significant problems which hinder the implementability of the soil extraction process at the Site. At present, no companies have been permitted by the State of California to operate transportable treatment units for the extraction of pesticide wastes from soils (personal communication, Mr. Alan Leavitt, Levine•Fricke, and Mr. Mark Fong, DHS, June 20, 1990). EPA has not identified companies which provide soil extraction of pesticide wastes or identified any Superfund sites where the soil extraction process has been performed for this type of soil contamination (EPA, 1986).

However, two companies have been identified which are developing this process option for the extraction of polychlorinated biphenyl (PCB) compounds from soil and sludge. These companies were contacted as part of the FS Report because PCBs have similar characteristics as the chlorinated pesticide indicator chemicals for the Site (e.g., extremely low solubility in water, high solubility in organic solvents, and high sorption coefficient for soils).

The first company, ENSR Corporation (Houston, Texas), has performed some bench-scale testing for PCB-contaminated soils, but has not yet completed any pilot scale or larger evaluations of its soil extraction process (personal communication, Mr. Leavitt and Mr. James Worthington, Manager of Operations, ENSR Corporation, March 21, 1990). The second company, Resources Conservation Company (RCC) (Bellevue, Washington), has developed a pilot-unit to treat PCB-contaminated soils at a site in Ohio. This unit has a 10-gallon capacity, and could treat approximately 50 pounds of soil per day (personal communication, Mr. Leavitt and Ms. Lisa Robbins, RCC, March 21, 1990). Since RCC has not performed any pilot-scale testing of soils which contain chlorinated pesticide residues, the soil extraction process has not been demonstrated to be implementable for this type of hazardous waste.

Cost
The cost of implementing soil extraction would be very high compared with other physical treatment process options. These costs would initially include laboratory, bench, and pilot testing of soils from the Site. If these preliminary studies were successful, much greater costs would be expended to design, construct, and operate a full-scale treatment unit. Operation costs would include the energy requirements to mix soil/extractant suspensions, separate solids and liquids, evaporate spent extractant, and dry the extracted soils. Subsequent treatment and disposal of the concentrated extractant would be another cost which could be very high.

Overall Evaluation
As previously noted, soil extraction has not been demonstrated to be an effective process option for soils contaminated with chlorinated pesticide wastes. No companies have been permitted to operate transportable treatment units capable of implementing soil extraction in California, and very few companies are known to be currently developing this treatment process. Finally, even if the method were developed, it would be relatively expensive to implement, given the expected treatment and disposal costs.

### 3.3.7.2 Process Option: Fixation

Fixation is a treatment process for immobilizing the contaminants within the affected soils. Contaminants are stabilized by adding materials such as portland cement, fly ash, asphalt, organic polymers, or other proprietary components to the soil matrix. This process generally does not alter the toxicity or chemical structure of the hazardous waste, but changes the physical structure of the original soil matrix. The fixation process usually is implemented to reduce the potential for soluble components to leach from the soil into ground water. Fixation might also improve the handling characteristics of soils with a high moisture content.

Depending on site conditions and the nature of the contamination, fixation could be performed in situ or with excavated soils using a batch process. In situ fixation would require augers, pumps, and injectors to forcibly apply the fixative into the subsurface soil matrix. Aboveground batch treatment of excavated soils could be accomplished using conventional cement mixing and handling equipment. After treatment, the fixed soil would be contained on site or disposed at an approved off-site facility.

Effectiveness
Fixation has proven to be most effective with wastes which exhibit a high potential to migrate from soil into ground water. For example, this process option has been used to prevent heavy metals from leaching from wastes into ground water. However, as discussed in Section 4.0 of the RI Report, the indicator chemicals for the Site already have extremely low solubilities in water, and tend to adsorb tightly to soils. These basic chemical properties have been confirmed by ground-water analyses and leaching tests using the California Waste Extraction Test (HLA, 1986b). In fact, a previous bench-scale fixation study of soils at the Site indicated that both treated and untreated soil samples had leachable DDT concentrations which were below the soluble threshold limit concentration for this chemical (HLA, 1986b). Therefore, fixation does not appear to appreciably reduce the solubility of DDT in soil at the Site compared to the existing low leaching potential for these soils.

Implementability
The fixation process would be readily implementable using conventional earthmoving and cement mixing equipment. There are a number of companies which could potentially apply this process with affected soils at the Site.

Cost
The cost of this process option would be considered moderate compared with other treatment options. Capital costs would include bench-scale studies, pilot-testing, and the design and construction of a full-scale treatment unit. Operation and maintenance costs would include energy, labor, feedstock, and final disposal costs for the treated wastes. The addition of fixatives would significantly increase the volume of the affected soils. For example, EPA has reported that the use of portland cement may increase the volume of wastes by 100 to 250 percent (EPA, 1986). If treated soils were disposed of at an off-site facility, this increase in bulk could significantly increase disposal costs.

Overall Evaluation
Fixation would not reduce the toxicity of the indicator chemicals at the Site, and may not significantly reduce the mobility of these substances. However, the addition of

fixatives would significantly increase the volume of the affected soils. Therefore, this process option has not been retained for further consideration in this FS Report.

3.3.8 REMEDIAL TECHNOLOGY: CHEMICAL TREATMENT

3.3.8.1 Process Option: Dechlorination

This process employs a chemical reaction to remove chlorine from organic compounds. It has been used primarily for the dechlorination of PCBs in transformer oils. The chemical reaction typically uses an alkali metal (sodium or potassium) and polyethylene glycol (PEG). The dechlorination reaction mechanism consists of the nucleophilic displacement of chlorine atoms by PEG to form sodium chloride and a substituted organic polymer (EPA, 1986).

Since the reagents are sensitive to air and water, the dechlorination process must take place in a reaction vessel under a nitrogen atmosphere. The water content of the contaminated soil must be reduced to approximately 0.2 percent or less, prior to treatment. The dried soil is mixed with the alkaline PEG to form a slurry within the reactor vessel. The slurry is heated to approximately 15°C for the duration of the reaction. Following dechlorination, the solids and liquids must be separated by centrifugation, filtration, or another suitable method. After the soils are washed with water and dried, they could potentially be disposed as nonhazardous waste, assuming that dechlorination was complete. The other wastes, including the spent PEG feedstock and washwater, would need to be tested for residual pesticides, and further treated, if necessary, prior to disposal.

Effectiveness
The dechlorination process has been demonstrated to be effective for PCB transformer oils. However, there is much less performance data for the treatment of PCB-contaminated soils, and no information has been identified to establish that the dechlorination process would be effective for soils containing high concentrations of chlorinated pesticides. Bench- and pilot-scale treatability studies would need to be performed to further evaluate the effectiveness of this process option at the Site.

As with the soil extraction process previous described, a rigorous mixing process would be required to break up clumps of soil into fine-grained sediments to effectively remove these compounds from affected soils. Additionally, the solid/liquid separation process could be difficult to perform due to the high percentage of silt- and clay-sized sediments in the affected soils.

Implementability
Implementation of the soil dechlorination process at the Site could be very difficult. At present, no companies have been permitted by the State of California to operate transportable treatment units for the dechlorination of pesticide wastes from soils (personal communication, Mr. Leavitt, Levine•Fricke, and Mr. Fong, DHS, June 20, 1990). One company, Galson Remediation Corporation (Syracuse, New York), has developed a pilot unit which has been used for treatability studies of PCB contaminated soils (personal communication, Mr. Leavitt and Mr. Dick Tavelli, President, Galson Remediation Corporation, March 16, 1990). However, to date, Galson Remediation Corporation has not performed any pilot-scale testing of soils which contain chlorinated pesticide residues.

Cost
The cost of implementing the dechlorination process option could be very high. These costs would initially include laboratory, bench, and pilot testing of soils from the Site. If these preliminary studies were successful, much greater costs would be expended to design, construct, and operate a full-scale treatment unit. Operation costs would include the energy requirements to mix and heat the soil/PEG slurry, separation of the solids and liquids, washing and drying the treated soils, and disposal of wastes generated by the process. The feedstock costs would also be significant. EPA has reported that this dechlorination process would not be cost effective for wastes containing PCBs at concentrations greater than 5,000 ppm, due to the excessive sodium requirements which would be required (EPA, 1986). Given the chemical similarities between PCBs and the chlorinated pesticides present at the Site, it may be assumed that the chemical feedstock costs would be similarly high for treatment of soils at the Site.

Overall Evaluation
To summarize the above discussion, dechlorination has not been demonstrated to be an effective process option for soils contaminated with chlorinated pesticide wastes. No companies in California have been permitted to operate transportable treatment units capable of implementing soil dechlorination, and relatively few companies are available to implement this

treatment process elsewhere in the United States. Finally, even if the method were developed, it would be very expensive to implement, given the expected treatment and disposal costs.

### 3.3.9 REMEDIAL TECHNOLOGY: THERMAL TREATMENT

#### 3.3.9.1 Process Option: Incineration

The incineration process consists of the combustion and thermal oxidation of organic compounds in an industrial kiln or furnace. Incineration has the potential to destroy the chemicals of concern with an efficiency of 99.99 percent or greater. The resulting breakdown products consist primarily of gases, scrubber wastes, and ash. Emission control devices would be required to prevent unacceptable emissions of gases or particulates from the incineration system. The remaining ash, combusted soil, and scrubber waste may require further treatment prior to final disposal.

The rotary kiln is the most widely used incinerator for contaminated soils. This type of incinerator can handle a broad range of wastes while achieving a high destruction efficiency. Other incineration systems, including multiple hearth furnaces and fluidized bed incinerators, have the potential for soil treatment, but are not generally designed or operated for this type of waste stream.

Rotary kilns consist of a cylindrical refractory-lined combustion chamber which may be fueled by natural gas, oil, or coal. The combustion chamber rotates as the contaminated soil is fed through the kiln. Typical residence times are approximately one hour, and combustion temperatures may range from 1,500°F to 3,000°F (Rich and Cherry, 1987). Several companies have developed mobile rotary kilns which could potentially be used to treat soils at the Site. However, the DHS has not yet issued permits to any incinerators to operate as transportable treatment units in California (personal communication, Mr. Leavitt and Mr. Fong, DHS, June 20, 1990). Moreover, no off-site commercial incineration facilities in California have received permits to treat contaminated soils. The closest commercial incinerator which could treat soils from the Site is operated by Rollins Environmental in Deer Park, Texas.

Effectiveness
Rotary kiln incineration could significantly reduce the volume and toxicity of contaminated soils from the Site. As noted in Section 2.2.3 of this FS Report, EPA has identified incineration as the BDAT technology for the chlorinated pesticides selected as indicator chemicals for the Site.

Implementability
On-site incineration of chemical-affected soils at the Site could be extremely difficult to implement, given the current unavailability of permitted transportable treatment units in California. It would be possible to transport contaminated soils from the Site to a permitted off-site incineration facility. However, there would be short-term risks in transporting these soils to out-of-state facilities. As noted in Section 2.2.3 of this document, EPA identified a national shortage of permitted incineration facilities that can treat contaminated soil and debris. Therefore, given the backlog of hazardous wastes awaiting treatment by this process, considerable time may be required before soils excavated from the Site could be disposed using incineration.

Cost
Incineration would be extremely expensive to implement, given the transportation costs to haul the affected soils to an off-site treatment facility, the high energy costs required to adequately combust soils, and the national shortage of incineration facilities which have been permitted to treat hazardous wastes.

Overall Evaluation
Incineration would effectively reduce the toxicity and volume of contaminated soils by destroying the chemicals of concern. However, this treatment technology would be extremely expensive to implement, and only a limited number of facilities have permits to treat contaminated soils. Because of these constraints, this process option has been retained for those soils containing very high chlorinated pesticide concentrations, which could not be disposed at a landfill without treatment.

### 3.3.9.2 Process Option: Vitrification

Vitrification is a thermal treatment process which converts soil into an inert, stable, glass-like product. Vitrification could be implemented as an aboveground batch process or as an in situ process using an array of electrodes inserted into the ground. With either method, the electrodes would be supercharged to establish an electrical current in the starter path. The starter path and surrounding soils would be heated to temperatures of 3,600°F, well above the initial melting temperature of most soils (between 2,000°F and 2,500°F). As the soil melts, it would be transformed into a glass-like product. Upon cooling, this vitrified soil would become a stable noncrystalline solid. To control emissions, a hood may need to be placed over the processing zone, and the combustion gases would be drawn into a gas treatment system.

Effectiveness
The vitrification process would potentially be effective in reducing the toxicity of the indicator chemicals at the Site. However, actual performance data are quite limited, since there have been relatively few applications of this process using contaminated soils. Pilot-testing would need to be performed to evaluate the effectiveness of this process under actual conditions at the Site.

Implementability
Very few companies in the United States have the capability to vitrify contaminated soils. No companies with transportable treatment units have been permitted for the vitrification process option in California (personal communication, Mr. Leavitt and Mr. Fong, DHS, June 20, 1990). Since the vitrification process requires very specialized equipment and highly trained personnel who are not readily available, implementation of this treatment option would be extremely difficult at the Site.

Cost
The vitrification process would be very expensive to implement, due to the high energy requirements, specialized equipment, and limited availability of qualified personnel to carry out this treatment method.

Overall Evaluation
The vitrification process has been screened out in the development of remedial alternatives, due to its unproven effectiveness, limited availability, and very high cost to implement.

### 3.3.10 REMEDIAL TECHNOLOGY: OFF-SITE DISPOSAL

#### 3.3.10.1 Process Option: Off-Site Land Disposal

The off-site land disposal process option consists of excavating soils with the highest chlorinated pesticide concentrations and transporting them to a suitable permitted hazardous waste disposal to a suitable permitted hazardous waste disposal facility. If the RCRA land disposal restrictions are applicable, this soil might require treatment prior to off-site land disposal. The treatment process options would be similar to those previously described.

Effectiveness
The off-site disposal option would be effective in reducing the volume of hazardous waste at the Site; however, the excavation and transportation of large quantities of contaminated soil would create short-term risks to human health and the environment.

Implementability
The off-site disposal process option would be implementable for contaminated soil. Soils could be excavated and hauled using conventional earth-moving equipment. However, since relatively few hazardous waste disposal facilities have permits to accept this material, it may be necessary to transport the soils over relatively long distances to an approved facility. Although certain hazardous wastes have been restricted from land disposal without treatment, EPA has issued a national capacity variance which might temporarily allow land disposal of contaminated soil and debris from the Site without treatment, because of the very limited capacity of approved hazardous waste treatment facilities.

Cost
The cost for implementing the off-site disposal process option would be relatively high. The closest Class I landfill is operated by Chem Waste Management at a location near Kettleman City, California, approximately 220 miles from the Site. Soils containing significantly elevated concentrations of chlorinated pesticides may require treatment and/or disposal at permitted facilities located considerably further away. For example, the closest incineration treatment facility is operated by Rollins Environmental, in Deer Park, Texas. Transportation to either of these facilities would be expensive. If off-site treatment would be required, the costs would be extremely expensive compared to land disposal without treatment.

Overall Evaluation
Although off-site treatment and/or disposal of soils could be very costly, it would effectively reduce the volume of hazardous wastes at the Site. This option will be retained for soils containing the highest concentrations of the indicator chemicals.

## 3.4 Remedial Technologies and Process Options for Embankment Sediments

### 3.4.1 REMEDIAL TECHNOLOGY: "NO ACTION"

#### 3.4.4.1 Process Option: "No Action"

As with upland area soils at the Site, the "no action" alternative serves as a baseline for comparison with other remedial alternatives and is required to be considered under CERCLA and the NCP. With this technology, no remedial technologies would be implemented. Various institutional actions and periodic environmental monitoring would be incorporated into the "no action" alternative.

### 3.4.2 REMEDIAL TECHNOLOGY: LAND-USE RESTRICTIONS

#### 3.4.2.1 Process Option: Deed Restrictions

This process option would be the same as previously discussed for upland soils at the Site (see Section 3.3.2.1). Since deed restrictions would be effective, implementable, and relatively low in cost to implement, this process option has been retained for consideration in the development of remedial alternatives for the embankment portion of the Site.

### 3.4.3 REMEDIAL TECHNOLOGY: SITE ACCESS RESTRICTIONS

#### 3.4.3.1 Process Option: Access Control Measures

This process option would be the same as previously discussed for upland soils at the Site (see Section 3.3.3.1). The existing site access restrictions are believed to be effective, and would be relatively low in cost to maintain in the future. Therefore, this process option has been retained for consideration in the development of remedial alternatives for the embankment portion of the Site.

### 3.4.4 REMEDIAL TECHNOLOGY: ENVIRONMENTAL MONITORING

#### 3.4.4.1 Process Option: Visual Inspections

Environmental monitoring for the embankment area would include visual inspections of the shoreline and related containment structures which might be constructed as part of site remediation (e.g., sheet pile walls, revetments). The effectiveness, implementability, and cost of environmental monitoring would be similar to that described for upland area soils (see Section 3.3.4.1).

### 3.4.5 REMEDIAL TECHNOLOGY: EXCAVATION OF EMBANKMENT SEDIMENTS

#### 3.4.5.1 Process Option: Excavate Embankment Sediments

This option would consist of removing embankment sediments from selected areas with a backhoe or other conventional earthmoving equipment. After excavation, embankment sediments would need to be contained, treated or disposed using other remedial technologies.

Effectiveness
Excavation of contaminated sediments from selected areas could effectively reduce the potential mobility of indicator chemicals at the Site. Contaminated sediments would be moved from the intertidal zone, where they are susceptible to surface water erosion, to a more secure on-site or off-site location for subsequent treatment and/or disposal. There would be potential short-term risks to human health and the environment during the excavation process (e.g., worker exposure to contaminated sediments and the discharge of sediments into the Lauritzen Canal). However, these risks would be minimized by adherence to an approved health and safety plan. As discussed in Section 1.2.2.3, over 800 cubic yards of embankment sediments from the most highly contaminated shoreline areas have already been excavated and disposed off site. An additional 400 cubic yards of sediment have been contained at an on-site upland area pending final cleanup at the Site.

Implementability
The implementability of this option would depend on the extent and location of embankment sediments proposed for excavation. Removal of this material could be accomplished by heavy equipment operators using conventional excavation equipment. However, excavation activities could be significantly complicated by the presence of existing structures at the Site, including the pile-supported wharf. This structure would require at least partial dismantling to provide access during the excavation. If possible, excavation activities would be conducted during periods of low tide, to avoid any underwater removal activities along the shoreline. Shoreline excavation and related activities would need to be timed with facility operations to minimize the amount of time that facility operations would be disrupted.

Cost
The cost of excavating embankment sediments would depend largely upon the location and extent of material to be excavated. Costs could be significantly increased by the presence of the pile-supported wharf, and the disruption of normal operations at LRTC's facility. If temporary sheet piling and/or dewatering of the embankment area would be required, then the excavation costs could be very high. The costs for treatment and/or disposal of excavated sediments would be very high, as previously discussed for upland soils.

Overall Evaluation
Excavation will be retained for consideration for alternatives to cleanup embankment sediments.

3.4.6 REMEDIAL TECHNOLOGY: SHORELINE STABILIZATION

3.4.6.1 Process Option: Revetments

This process option would reduce erosion of chemical-affected embankment sediments by placing an erosion-resistant facing (i.e., revetment) along the eastern shoreline of the Lauritzen Canal. A revetment would create a physical barrier over the slope, minimizing contact of canal water against embankment soils and stabilizing the shoreline against surface water erosion. For proper installation, portions of the embankment may need to be graded, and existing abandoned structures may need to be removed. Embankment sediments with significantly elevated pesticide concentrations would probably be transferred to other on-site or off-site locations prior to revetment construction. The revetment types considered under this process option include gunite, sacrete, rock riprap, concrete, asphalt, and asphalt mastic.

Effectiveness
Revetment construction is a proven method to protect shorelines against erosion (U.S. Army Corps of Engineers, 1985). The long-term effectiveness of this process option would depend on the durability of the facing material and the quality of the construction. No shoreline stabilization methods would reduce the toxicity or volume of contamination. However, if properly installed and maintained, this process option would effectively control the migration of chemical-affected embankment sediments from the Site.

Implementability
The implementability of this option would depend on site-specific factors, including the type of revetment material used, the presence of existing structures that could

interfere with construction work, and the depth at which the revetment is installed below sea level. Although it would not be necessary to obtain permits for remedial activities conducted entirely on site, this process option would need to be implemented in accordance with the applicable regulations administered by BCDC and the U.S. Army Corps of Engineers.

A revetment could be constructed over exposed portions of the embankment which extend above sea level. However, it would be extremely difficult to place a revetment under water or below the existing pile-supported wharf. Asphalt and gunite facings would be particularly difficult to apply under water. Quality control is also a potential problem. Asphalt mastic (consisting of a layer of riprap bound by pouring hot asphalt over it) would contain an additional step of placing riprap on the slope, in addition to applying asphalt. In underwater construction, the mastic cools too quickly to effectively penetrate and bind the stones.

If a sacrete revetment were proposed, the underwater portion of the revetment would require divers to place the majority of concrete-filled sacks, or the concrete could be pumped down to the final sack location and divers would position the sack appropriately. Driving rods through the sacks (for added stability) would be extremely difficult. The constructibility problem would only be compounded under the wharf, where pilings are present and overhead access/clearance is limited.

A riprap revetment would require sections of the existing slope to be flattened to a 2H:1V slope. This might require the piles north of the wharf to be cut off and appropriately disposed. Placement of riprap under the wharf would be extremely difficult to perform. If placement was carried out from the water, the barge used for placement would need to be large enough to handle the stones, yet small enough to maneuver among the piles. Alternatively, sections of the wharf planking would have to be removed to enable riprap placement from above the water.

A concrete revetment could either be cast in place or prefabricated. A cast-in-place revetment could be carried out above the water line by placement around existing piles. A low-slump mix would be required so that the concrete would not significantly slump down the slope before setting. Drainage holes would need to be provided for relief of hydrostatic pressure. Underwater placement would be more difficult, increase costs, and decrease quality control. A cast-in-place revetment would produce a smooth slope with higher runup than an articulated slope or riprap slope.

Installation of a prefabricated concrete revetment would be complicated by the presence of numerous piles along the shoreline. Abandoned piles would need to be cut to grade and disposed appropriately. The existing wharf would need to be integrated into the revetment using precast sections of concrete mat designed to fit around the support piles. Prefabricating the mat with holes would necessitate exact measurement of existing pile locations transferred to the manufacturer. Joining mat sections around piles would require irregular overlapping or cutting of the mat sections and would need manufacturer approval. A filter fabric placed under the mat must also address these requirements.

Even if a revetment is properly installed, its presence along the embankment would make it very difficult to drive new piles for future maintenance of the wharf.

Cost
The costs for a revetment covering the eastern shoreline of the Lauritzen Canal would depend on site access conditions. It would be relatively inexpensive to install a revetment along exposed sections of the shoreline which are above sea level. However, it would be very expensive to construct a revetment under water or below the wharf. The use of divers in marine construction work would significantly increase project costs. Additional costs might include cutting and disposing of abandoned piles, and removal and replacement of existing wharf planking.

Overall Evaluation
If properly installed, a revetment could effectively reduce erosion and contain shoreline sediments. However, most of the embankment area is virtually inaccessible, and would require dismantling of the pile-supported wharf prior to construction. Portions of the embankment might also need to be graded to reduce the slope. Notwithstanding these factors, it would be difficult to properly install an erosion resistant facing under water. Moreover, the presence of a revetment would make it difficult to perform continuing maintenance on the pile-supported wharf. Therefore, this process option has been screened out.

### 3.4.6.2 Process Options: Seawalls and Bulkheads

This process option would prevent the erosion of shoreline sediments through the construction of a seawall or bulkhead along the toe of the embankment. Dredged sediments could be placed behind the wall, further stabilizing the shoreline and minimizing the amount of open-water fill within the Lauritzen Canal. Seawalls or bulkheads could be installed outboard of the existing wharf at the Site.

Seawalls are massive structures designed to resist wave action. They are commonly constructed of concrete or stone, and are gravity or pile supported. Bulkheads are retaining walls that separate areas of higher and lower elevation while providing protection against light to moderate wave action. They are used for marinas, wharfing facilities, and other structures where deeper water is needed directly at the shore. Bulkheads may be cantilevered or anchored sheet piling, or gravity structures such as rock-filled timber cribbing. Since a minimum cross-sectional area for the structure is desired (to increase possible storage capacity behind the wall and to reduce construction costs), gravity structures may be screened out of the process options.

<u>Effectiveness</u>
Seawalls and bulkheads should be designed to withstand wave action and maintain their integrity for the design life of the structure. A sheet pile wall bulkhead driven into the underlying sediments and anchored properly would effectively lower the potential for erosion of shoreline sediments. A seawall may also provide adequate protection; however, as noted below, a seawall would be more complicated to construct.

<u>Implementability</u>
As with revetments, seawalls and bulkheads would need to be constructed in accordance with the applicable requirements of BCDC and the U.S. Army Corps of Engineers. Standard marine engineering and construction techniques could be used to construct a seawall or bulkhead at the Site.

Because of their large mass and size, seawalls need proper foundation preparation. A seawall constructed along the Lauritzen Canal shoreline would need dredging and backfilling along its alignment prior to placement of the structure. The structure itself would need to have a large cross sectional area and might therefore require significant grading to modify the existing slope of the canal bottom. This construction work could increase the turbidity and degrade water quality in the canal, creating short-term environmental risks.

Bulkheads would be easier to construct than seawalls, and would be much less likely to disturb bottom sediments in the canal. Anchored sheet pile bulkheads are commonly constructed of timber, concrete, aluminum, or steel. The bulkhead is anchored to the slope using a tieback system. Horizontal wales distribute lateral loads on the structure to the anchors. Cantilevered bulkheads are generally engineered for heights less than 15 feet; therefore, an anchored bulkhead would be more appropriate for use in the Lauritzen Canal, which ranges in depth from approximately 20 to 38 feet. The following discussion describes the materials most commonly used to construct sheet pile bulkheads.

Timber

Timber treated with corrosion-resistant metals has been successfully used in marine bulkheads. A filter is usually recommended for placement behind timber sheeting to minimize sediment migration. Because the joints between timber piles are a greater consideration with timber than in concrete or steel sheet piles, and because of the relatively low strength and relatively short lifespan of timber piles, timber piles were not considered further in this study.

Concrete

Prestressed concrete sheet piling has been widely used in marine bulkheads. It is generally constructed with tongue-and-groove edges which guide the adjacent pile while driving and provide a relatively tight seal. Standard dimensions of concrete piles vary from about 12 to 16 inches in thickness by approximately 3 feet in width. Piles can be cast to any reasonable dimension upon specification.

A concrete sheet pile wall could be engineered to be essentially impervious. This would be achieved with a standard tongue-and-groove joint from the base of the wall to approximately 5 feet below the mudline. From that point to the top of the wall, another tongue-and-groove interlock would be used. This alternative interlock would have a deeper groove which would create a gap between the tongue and the groove. After driving, this gap would be jetted clean of soil then grouted from bottom to top to completely seal the tongue-and-groove interlocks. However, since the indicator chemicals at the Site have very low solubilities, and ground water does not appear to be a significant route of chemical migration, an impervious wall is not considered necessary for containment of shoreline sediments.

Long sheet piles constructed of concrete have been found to be susceptible to breakage during driving. Because the required height and depth of embedment for portions of this project necessitate the use of long piles (approximately 70 to 80 feet long), concrete is not recommended for the sheet piling material.

Aluminum
Aluminum sheet piling has excellent corrosion resistance (U.S Army Corps of Engineers, 1985). It has a high strength-to-weight ratio and is light in weight. The primary disadvantage of aluminum is that it cannot be driven through logs, rocks, or other hard obstructions. The high strengths necessary for this bulkhead may make aluminum an inappropriate material for stabilizing the Lauritzen Canal shoreline.

Steel
Steel sheet piling is the most commonly used bulkhead material. It can be driven into hard sediment. Various grades and thicknesses of steel are used, depending on a project's requirements. Two considerations regarding steel piling are interlock seepage and corrosion. If dredged sediments are used as backfill behind the wall, measures should be taken to minimize migration of sediments through the interlocks (and weep holes, if constructed). To accomplish this, a geotextile should be placed along the back side of the steel wall to minimize the potential for sediment migration into the canal.

The other consideration for steel sheet piling is corrosion. Several forms of corrosion protection have been used and tested by government agencies and private industry. Based on literature from the U.S. Army Corps of Engineers and the National Bureau of Standards, a combination cathodic protection and coating (such as coal tar epoxy) of the piling would effectively control corrosion. Cathodic protection has proved effective in the immersed section of the piling. The section not fully submerged (the splash zone) could be protected by a cast-in-place concrete cap.

Construction of the bulkhead would include driving the sheets, backing the sheets with a geotextile layer, driving the batter H-piles, installing the wales, tie rods, and supports, and casting the concrete caps. The dredged sediments would then be placed behind the wall and appropriately capped.

Cost
The cost for an anchored bulkhead may exceed that for a revetment. The use of steel sheet piles that could withstand pressures from backfill sediments, and an anchoring system that could adequately hold the bulkhead, would require a highly engineered design, including materials selection and quality construction.

Overall Evaluation
Construction of a seawall has been screened out because of necessary foundation preparation and final structure cross section.

Construction of an anchored steel sheet pile bulkhead is recommended along the toe of the Lauritzen Canal embankment. The steel sheet pile wall, if properly constructed, would minimize migration of sediments into the canal. This bulkhead could be protected from corrosion by being coated, cathodically protected, and capped with concrete in the splash zone. Such a structure would provide the necessary strength and reduction of sediment migration required for this project.

3.4.7 REMEDIAL TECHNOLOGY: PHYSICAL TREATMENT

3.4.7.1 Process Option: Soil Extraction

This treatment option would be similar to that previously described for upland area soils (see Section 3.3.7.1). As previously noted, soil extraction has not been demonstrated to be an effective process option for soils contaminated with chlorinated pesticide wastes. The limited availability of companies able to perform this process would hinder its implementability at the Site, and would make development of this process costly. Therefore, soil extraction has been screened out as an option for the treatment of embankment sediments at the Site.

3.4.7.2 Process Option: Fixation

This treatment option would be similar to that previously described for upland area soils (see Section 3.3.7.2). However, in situ fixation would not be appropriate for embankment sediments. Instead, this process would be implemented as a batch treatment process with excavated sediments. As with the upland soils, fixation would not reduce the leachability of the indicator chemicals, which already have very low solubilities and high soil adsorption coefficients. Therefore, this process option has been screened from further consideration for the embankment sediments.

3.4.8 REMEDIAL TECHNOLOGY: CHEMICAL TREATMENT

3.4.8.1 Process Option: Dechlorination

This process option would be similar to that previously described for upland soils (see Section 3.3.8.1). As with soils, dechlorination has not been demonstrated to be an effective process option for treating sediments containing chlorinated pesticides. Additionally, this process is not readily implementable due to the limited number of companies which are developing this technology. Therefore, dechlorination has been screened out as a process option for treating embankment sediments at the Site.

3.4.9 REMEDIAL TECHNOLOGY: THERMAL TREATMENT

3.4.9.1 Process Option: Incineration

This thermal treatment process would be as previously described for upland soils (see Section 3.3.9.1). As with upland soils, incineration would be effective in reducing the volume and toxicity of contaminated embankment sediments. However, it would be very costly to treat the embankment sediments by incineration due to the transportation and energy requirements for this process. Additionally, since there is very limited incineration capacity currently available for contaminated soil and debris, there may be significant delays in treating embankment sediments by this method. As with the upland area soils, the incineration process option has been retained for use with those embankment sediments which could not be disposed at a landfill without treatment.

3.4.9.2 Process Option: Vitrification

This thermal treatment process would be as previously described for upland soils (see Section 3.3.9.2). As with upland soils, the vitrification process has been screened out in this FS, due to its unproven effectiveness, limited availability, and very high implementation cost.

3.4.10 REMEDIAL TECHNOLOGY: OFF-SITE DISPOSAL

3.4.10.1 Process Option: Off-Site Land Disposal

The off-site land disposal process option consists of excavating chemical-affected embankment sediments and transporting them to a suitable permitted hazardous waste disposal facility. The effectiveness, implementability, and cost would be similar to that previously discussed for upland soils (see Section 3.3.10.1). This process option has been retained for further consideration in the development of remedial alternatives for the Site.

### 3.5 Remedial Technologies and Process Options for Lauritzen Canal Offshore Sediments

#### 3.5.1 REMEDIAL TECHNOLOGY: "NO ACTION"

3.5.1.1 Process Option: "No Action"

As with upland area soils at the Site, the "no action" alternative serves as a baseline for comparison with other remedial alternatives and must be considered under CERCLA and the NCP. With this technology, no remedial technologies would be implemented. Various institutional actions and periodic environmental monitoring would be incorporated into the "no action" alternative.

Effectiveness
Since all existing remedial efforts would cease, there would be virtually no reduction in the toxicity, mobility, or volume of chemicals from the embankment sediments. As described in the remedial action objectives, the potential risks associated with the Lauritzen Canal sediments relate primarily to their availability to estuarine organisms. The "no action" process option would not reduce the potential risks associated with these offshore sediments.

Implementability
The "no action" process option is implementable.

Cost
The "no action" process option has a very low cost in comparison to other process options.

Overall Evaluation
As required by CERCLA and the NCP, the "no action" alternative has been retained for further consideration.

#### 3.5.2 REMEDIAL TECHNOLOGY: WATER-USE RESTRICTIONS

3.5.2.1 Process Option: Water-Use Restrictions

The Lauritzen Canal is an active shipping channel used by LRTC and other industrial waterfront facilities. There are no boat ramps or other public shoreline facilities which permit direct access to the Lauritzen Canal. The absence of these features, combined with the heavily industrialized use of the Lauritzen

Canal, significantly discourages public access to this area. Nevertheless, signs have been posted along the pile-supported dock at the Site to warn people that canal sediments, fish, and shellfish may be contaminated with DDT.

Effectiveness
Continued use of the Lauritzen Canal for port-priority activities would effectively discourage access to contaminated areas of the Site. The existing warning signs are believed to further reduce the potential for exposure to contaminated fish, shellfish, or sediments.

Implementability
Maintenance of the existing warning signs and continued designation of the Lauritzen Canal for port-priority use would be readily implementable.

Cost
The cost to maintain the existing warning signs would be very low.

Overall Evaluation
Water-use restrictions are already in place and will be retained for further consideration as a process option.

### 3.5.3 REMEDIAL TECHNOLOGY: ENVIRONMENTAL MONITORING

#### 3.5.3.1 Process Options: Visual Observations and Chemical Analyses of Offshore Sediments, Biota, and Surface Water

Environmental monitoring could be used to evaluate future site conditions under the "no action" alternative, as well as the long-term effectiveness of implemented remedial measures. Monitoring might also be necessary to confirm that short-term potential exposures remain at acceptably low levels during site cleanup activities (e.g., dredging of offshore sediments). Monitoring within the Lauritzen Canal would consist of sample collection and chemical analyses of surface water, offshore sediments, and marine organisms. These monitoring options are described below.

Visual Inspections
This type of monitoring could be used to evaluate site conditions under the "no action" alternative, as well as the performance of various remedial alternatives. For example, containment structures built at the Site (e.g., sheet pile walls, a rock dam, caps) could be visually monitored for signs of deterioration.

Surface Water Sampling
Surface water monitoring could be conducted periodically to evaluate the concentrations of indicator chemicals in the Lauritzen Canal. Although the indicator chemicals have an extremely low solubility in water (e.g., the reported solubility of DDT in water is 25 ppb), surface water monitoring would be an appropriate component for all remedial alternatives to evaluate water quality conditions over time.

Offshore Sediment Sampling
Offshore sediment quality has already been well characterized over most of the Lauritzen Canal. The existing data indicate that offshore sediments have chlorinated pesticide concentrations which range from less than 1 ppm up to several hundred ppm. However, additional sediment sampling is recommended to better define the vertical extent of contamination over a localized area near the western shoreline of the canal, prior to implementing any cleanup alternatives which include dredging.

After additional dredging is performed, it would be appropriate to collect sediment samples for chemical analyses to confirm that cleanup goals have been met and to establish a new baseline for monitoring the performance of the selected remedial alternative.

Marine Organisms
Previous biological monitoring at the Site has indicated that shellfish, fish, and other marine organisms are accumulating chlorinated hydrocarbon pesticides. Bioaccumulation monitoring could be conducted periodically to monitor future impacts on the marine biota in the Lauritzen Canal. This activity would be an appropriate component for all remedial alternatives, including the "no action" alternative.

Future biological sampling results could be used to confirm the effectiveness of the selected remedial alternative. Standardized protocols should be followed, so that the data are comparable over time. Sampling could be coordinated through the State Mussel Watch Program so that sampling results for the Lauritzen Canal could be directly related to a more extensive temporal and geographic database for the San Francisco Bay.

The effectiveness, implementability, and cost of environmental monitoring are discussed below.

Effectiveness
Environmental monitoring process options would not reduce the risks associated with potential exposures; however, they would be helpful in assessing the magnitude of exposures, chemical mobility and attenuation, and remedial effectiveness.

Implementability
Monitoring would be a readily implementable option for the Site. All media samples for laboratory analyses would be collected using appropriate protocols and submitted to a State-certified analytical laboratory for analysis. The specific monitoring program developed would depend on the remedial alternative selected for the Site.

Cost
The costs of environmental monitoring process options would be highly dependent on the type, frequency, and length of time such monitoring would be required. For relatively short monitoring periods (such as during dredging), costs would be low to moderate. For long-term monitoring, the costs would be relatively high.

Overall Evaluation
Environmental monitoring has been retained to evaluate future conditions at the Site. The specific monitoring options selected will depend on the scope of each remedial alternative, but will include visual inspections, and chemical analyses of surface water, offshore sediments, and marine organisms.

### 3.5.4 REMEDIAL TECHNOLOGY: SEDIMENT DREDGING

#### 3.5.4.1 Process Option: Hydraulic Dredging

This process option could be used to remove affected offshore sediments from the Lauritzen Canal, significantly reducing the potential for estuarine organisms to be exposed to indicator chemicals from the Site. Hydraulic dredges remove and transport sediment in liquid slurry form. Slurries of 10 to 20 percent solids by weight are common in standard hydraulic dredging operation (EPA, 1985). The hydraulic dredge is usually barge-mounted, and includes a centrifugal pump, suction line, and discharge pipe. A cutterhead on the suction line removes compacted clays in addition to soft alluvial materials. The suction end of the dredge is usually mounted on a moveable ladder which can be raised or lowered to control dredging depths. The slurries may be pumped through a floating or pontoon-supported pipeline to an on-site treatment/disposal area.

Effectiveness
Dredging would not reduce the toxicity or volume of affected sediments, but would greatly reduce the potential for estuarine organisms to come into contact with these sediments by removing the sediments from the marine environment. Subsequent treatment and/or disposal of the dredged sediments could significantly reduce their mobility at the Site. Dredging activities could pose a short-term risk if fine-grained benthic sediments were resuspended and transported over a wider area. This risk is generally minimal in a well-designed hydraulic dredging program. Additionally, design measures, including the use of silt curtains and low-turbidity dredge vessels, could be used to reduce turbidity to acceptably low levels while dredging.

The overall effectiveness of this option is contingent upon the ability to control the areal extent and depth of the dredging operation, as well as the integrity of the final containment facility.

Implementability
Conventional hydraulic dredging equipment (e.g., cutterhead dredge) is readily available in the Bay Area. Use of other less common hydraulic dredges (e.g., plain suction, dustpan, or hopper dredges) may be more difficult due to limited availability, mobilization, and potential scheduling problems. While it may not be necessary to obtain permits from BCDC or the U.S. Army Corps of Engineers for dredging in the Lauritzen Canal as part of the Superfund cleanup, it would be necessary to coordinate the planned cleanup of offshore sediments with these agencies and to meet all substantive State and federal requirements which are determined to be ARARs for the Site.

Using the hydraulic dredging process option, a slurry could be readily pumped behind a sheet pile wall, rock dam, or similar containment structure in the Lauritzen Canal. Alternatively, if the dredged sediments were to be disposed at an upland area of the Site, they would need to be appropriately conditioned. The slurry would require settling, dewatering, and possibly other physical treatment methods to stabilize and consolidate the dredged sediments. If an off-site disposal facility is used, additional sediment treatment (e.g., fixation) may be required for transport. These activities may need to be staged over a period of several years or more, because of the limited on-site area available to treat and/or dispose of the dredged sediments. However, it may be possible to expedite this schedule with more intensive treatment methods, such as the use of coagulants, filtration, or thermal drying methods. The feasibility of these treatment methods would need to be confirmed with proper pilot testing.

Additionally, it may be necessary to contain and treat water generated from dewatering of dredged sediments. In that case, additional on-site areas would be required to treat dredge return water prior to discharge to the Lauritzen Canal. Pilot testing would also be required to design an appropriate treatment method for processing this water.

Cost
The cost for hydraulic dredging would be similar to or slightly higher than mechanical dredging options. However, these costs would be significantly increased if extensive treatment is required for return dredge water. LRTC could incur significant additional costs if dredging and related dewatering operations interfered with ongoing business activities at the existing terminal facility.

Overall Evaluation
Hydraulic dredging would be an effective process option to remove affected sediments from the Lauritzen Canal, particularly if the resulting slurry could be disposed behind a sheet pile wall, rock dam, or similar containment structure. It would be necessary to control turbidity through appropriate dredging procedures. This process option has been retained for further consideration in the development of FS alternatives.

### 3.5.4.2 Process Option: Clamshell Dredging

Clamshell dredges are crane-operated devices used to mechanically remove offshore sediments. As with the hydraulic dredging process option, clamshell dredging could be used to remove affected offshore sediments from the Lauritzen Canal, significantly reducing the potential for estuarine organisms to be exposed to indicator chemicals from the Site. In contrast to hydraulic dredging, clamshell dredging can be used to excavate almost any type of channel material at densities which are closer to in situ conditions. After removal, the affected sediments would need to be disposed at an on-site or off-site location.

Effectiveness
As with hydraulic dredging, this process option would not reduce the toxicity or volume of affected sediments, but would effectively remove them from the marine environment. The short-term risks of clamshell dredging are similar to those

associated with hydraulic dredging. According to EPA (1985), even under ideal conditions, substantial losses of loose and fine sediment will usually occur when using conventional clamshell buckets. Since these buckets are not watertight, some sediments would be released when the bucket is hoisted. When the bucket clears the water surface, sediments heaped above the rim of the bucket may also slump off into the water. Additionally, some sediments may be washed away as water rapidly drains out of the bucket. These problems can be partially controlled by the fit and condition of the bucket, hoisting speed, and other operational factors.

Recent work on environmental dredging projects has spurred interest in the use of closed clamshell buckets. In contrast to conventional clamshells, the closed clamshell bucket is designed with flexible gaskets which create a watertight seal, better containing the dredged material within the bucket. Therefore, this specialized bucket enables better removal of affected sediments with reduced resuspension of sediments during dredging.

Implementability

Conventional clamshell dredging equipment is readily available in the Bay Area. Use of a watertight closed clamshell would be preferable, but may be more difficult due to the limited availability of this type of bucket. As with hydraulic dredging, it would be necessary to coordinate the planned cleanup of offshore sediments with BCDC and the U.S. Army Corps of Engineers, and to meet all substantive State and federal requirements which are determined to be ARARs for the Site.

Since clamshell dredging would yield sediments with relatively high solids content, there would be less need to dewater or otherwise condition dredged materials prior to on-site or off-site disposal. The dredged sediments could be readily placed behind a sheet pile wall, rock dam, or similar containment structure in the Lauritzen Canal. If the dredged sediments needed to be disposed at an upland area of the Site, or at an off-site disposal facility, they would still need to be appropriately conditioned. However, sediments dredged with a clamshell would require significantly less treatment than those obtained by hydraulic dredging, due to lower water contents.

Cost

The cost for clamshell dredging would be similar to hydraulic dredging options. Production rates are usually lower with clamshell dredging, since the dredged material may need to be placed into a hopper barge, transported to a disposal site, and unloaded. However, these additional handling costs are offset by the lower costs to dewater dredged sediments and treat return water, if necessary. LRTC could incur significant additional costs if the dredging operations interfered with ongoing business activities at the existing terminal facility.

Overall Evaluation

Clamshell dredging would be an effective process option to remove affected sediments from the Lauritzen Canal. Use of a watertight closed bucket would be preferable to a conventional clamshell bucket. If upland or off-site disposal were required, then clamshell dredging would be preferable over hydraulic dredging, because of the limited site area which is available for dewatering sediments. Since clamshell and hydraulic dredging offer different advantages, both process options have been retained for further consideration in the development of FS alternatives.

3.5.5 REMEDIAL TECHNOLOGY: CONTAINMENT IN LAURITZEN CANAL

3.5.5.1 Process Option: Encapsulation with Multimedia Cap.

This process option would reduce the potential for estuarine organisms to become exposed to chemical-affected offshore sediments through the construction of a multimedia cap which would create a physical barrier over the bottom of the Lauritzen Canal. This multimedia cap would consist of an impermeable membrane, graded filter material, and armor rock over the existing canal sediments. This process option would require little or no dredging and would result in about 1 foot of submerged fill in open water areas of the Lauritzen Canal.

Effectiveness

In-place encapsulation with a multimedia cap would require underwater construction activities in relatively deep waters (i.e., 20- to 30-foot depths). If properly installed, this underwater encapsulation system would be expected to reduce future contact of estuarine organisms with affected sediments. However, as discussed below, it would be difficult to install membranes and rock media in this environment.

Geotextile membranes could not be sealed underwater. Therefore adjoining sections would need to be overlapped. Over a period of years, there is a potential for differential settlement of the multimedia cap over the soft Bay Mud. This differential settlement could stretch the membrane, or cause overlapping edges to separate, eventually leading to its failure. Even if differential settlement did not damage the cap, in-place encapsulation would not be compatible with the designated port-priority water-related use of the Lauritzen Canal. The placement of an impermeable membrane, filter material, and armor rock could interfere with future dredging requirements to maintain this waterway for navigation purposes.

Implementability
Underwater placement of membranes could be very difficult to properly implement. Divers would be used to install the membrane and visually inspect the construction work. The use of divers for this type of construction work would be potentially hazardous. Poor visibility would also make it difficult to adequately observe underwater conditions in the canal. If the in-place cover materials were not properly installed, the membrane could be torn or punctured by the overlying rock or by submerged objects in the canal. Future integrity of the membrane would also be difficult to ascertain, since it would be covered by rock, and would require underwater inspections.

Cost
The costs for in situ encapsulation would probably be similar to other process options for the containment of chemical-affected offshore sediments. The use of divers in marine construction work could make this option very costly. Additional costs might include mitigation for the placement of submerged fill into bay waters, and future lost income to waterfront facilities if the cap interferes with dredging to maintain the Lauritzen Canal as a shipping channel.

Overall Evaluation
In-place encapsulation has been screened out as a process option, because it would be difficult to implement, may not effectively contain chemical-affected offshore sediments, and could interfere with the future use of the Lauritzen Canal as a shipping channel.

3.5.5.2 Process Option: Containment Behind Rock Dam or Sheet Pile Bulkhead

This process option would use engineering controls to contain dredged sediments within a portion of the Lauritzen Canal. The specific types of containment structures considered under this process option include an anchored steel sheet pile wall, a rock dam, and a combination rock and steel sheet pile dam. These structures would be designed to contain contaminated sediments, significantly reducing or eliminating the future exposure of estuarine species to indicator chemicals at the Site.

The steel sheet pile wall has already been reviewed as a process option for stabilizing the eastern shoreline of the Lauritzen Canal (see Section 3.4.6.2 of this FS Report). As previously noted, dredged sediments could be placed behind this bulkhead, under the existing pile-supported wharf. The effectiveness, implementability, and cost of constructing a sheet pile bulkhead along the shoreline has already been evaluated.

A dam constructed from rock and/or steel sheet piling could be placed across the head of the Lauritzen Canal to contain the most significantly affected sediments at the Site. Since much of these sediments are already located in this part of the canal, they would be contained in situ (i.e., without needing to be dredged). The remaining storage capacity behind the dam could then be filled with less contaminated sediments dredged during the cleanup of other portions of the Lauritzen Canal. Appropriate mitigation (e.g., creation or restoration of an off-site wetland area) might be necessary to offset the bay filling required with this process option.

This process option would require extension of the existing 60-inch municipal storm water drain from its current location at the head of the Lauritzen Canal to the outboard side of the proposed dam. Since construction of a dam across the head of the canal would potentially impact other waterfront facilities, appropriate agreements would need to be arranged with the involved parties as part of this option.

Effectiveness

Steel sheet piling and rock are widely used in marine construction work. For example, steel sheet piling has been successfully used as a retaining structure in bulkheads for wharf and dock facilities. Rock has been successfully used in structures such as breakwaters, jetties, and groins. These control measures would not reduce the volume or toxicity of the offshore sediments. However, if properly engineered and constructed, this process option would effectively contain chemical-affected sediments. Since the indicator chemicals have extremely low solubilities and adsorb tightly to sediments, immobilization of these sediments would prevent significant migration of pesticides in the Lauritzen Canal. Moreover, by constructing a dam across the Lauritzen Canal, the most contaminated sediments would not need to be dredged.

The in situ containment of these sediments would minimize the potential short-term risks associated with dredging activities at the Site.

Steel sheet piling would require corrosion protection to extend its lifespan, whereas a rock dam would require relatively little maintenance after it is constructed.

Implementability
Conventional marine construction equipment could be used to implement this process option. Transport of rock would likely occur on barges; steel sheet piling would likely be shipped in by truck, rail line, or barge. Construction using either material would be carried out from the water. Although permits may not be required for this on-site cleanup work, it would be necessary to coordinate construction activities with BCDC and the U.S. Army Corps of Engineers. All substantive federal and State requirements which are determined to be ARARs would need to be implemented during site cleanup.

A single steel Z-section sheet pile wall could be driven from a barge to the required embedment depth. Once the sheet piling is in place, it would be necessary to anchor it to withstand the lateral pressures from backfill. Anchorage presents a major difficulty, however, because existing shoreline sediments would be up to several hundred feet from the proposed alignment of the sheet pile wall. This distance would be too large for an anchorage system to span; and if the anchorage were placed in the dredge sediments, the dredged sediments would not provide sufficient strength to support the containment structure. Therefore, it would be necessary to support the sheet pile wall using batter piles, deadmen, or other anchorage systems tied to the stiff clays below the canal bottom. The sheet pile would need to be protected from corrosion using cathodic protection, coatings, and/or a concrete cap.

Construction of a rock dam could be carried out using a bottom dump split hull barge or a large diameter pipe off the side of a barge to dump the rock and gravel. Construction would begin by subexcavation of approximately 8 feet of bottom mud to expose the stiff clay bearing layer. This would be backfilled with crushed coarse gravel to the surrounding mudline, and leveled with a heavy screed bar. Perimeter rock dikes would then be constructed on both sides of the dam centerline followed by gravel backfill dumped between the dikes. This sequence of dike construction with gravel backfilling would be repeated with each subsequent lift placed upon the previous one, until the dam reached final grade. The backside would be lined with several layers of geotextile or natural graded filter material (e.g., sand and gravel) to minimize seepage of fine material through the dam.

A combination sheet pile and rock dam structure would include a vertical steel sheet pile wall driven along the dam alignment, with rock placed on the outboard side and several geotextile layers placed on the inboard side. Use of the sheet pile would significantly reduce the amount of rock needed, thereby reducing the quantity of bay area which would need to be filled, and increasing the sediment storage capacity available behind the dam. Construction would begin with subexcavation to the firm material, followed by driving the sheet pile wall. The excavation would be filled with gravel. Several layers of geotextile would be placed on the inboard side of the sheet pile to provide filtration of dredged sediments to be placed on the inboard side. Rock would then be placed on the outboard side to approximately 10 feet above the foundation. As more rock was added to the outboard side, dredged sediments would be placed on the inboard side. This sequence would be followed until final grade was reached, keeping a maximum difference between outboard and inboard heights of 10 feet.

<u>Costs</u>
The costs for a rock dam would be relatively low compared to a single sheet pile wall, because of the expense involved in anchoring the sheet pile, and the greater costs which would be required for the long-term maintenance of the sheet pile. If divers were required to facilitate placement of the geotextile on the back side of the structure, construction costs for either option would be increased. Additional costs might include construction of a sheet pile wall around the perimeter of the dredged sediment containment area, capping the dredged sediments once in place, extending the existing storm water outfall, providing alternative docking facilities for adjacent property owners who would lose waterfront access, and possible mitigation for the elimination of bay area.

<u>Overall Evaluation</u>
A properly engineered and constructed structure could provide a containment area to store a large quantity of chemical-affected sediments. The use of geotextiles would minimize sediment migration through the structure. The use of rock would provide resistance to backfill pressures. Anchorage of a single sheet pile wall would be a significant problem which makes this option appear less feasible. A combination rock/sheet pile structure would reduce the foundation area (footprint) of the structure which in turn

would reduce open water fill and/or increase storage capacity behind the structure. For these reasons, a combination sheet pile/rock structure is considered the best alternative for this process option.

### 3.5.6 REMEDIAL TECHNOLOGY: CONTAINMENT IN UPLAND AREA OF SITE

#### 3.5.6.1 Process Options: Containment in Diked Areas or Excavated Ponds

This option would involve the disposal of affected Lauritzen Canal sediments in the Upland Area of the Site. After dredging, these sediments would be transferred to a diked area or excavated ponding basin where they would be consolidated, dewatered, and further conditioned, as necessary. The water which drains from these sediments might also require treatment before its discharge back into the Lauritzen Canal. After the sediments have been appropriately dried and compacted, they would be capped with clay and/or asphalt concrete.

Effectiveness
The on-site upland containment of dredged sediments would significantly reduce or eliminate the future exposure of estuarine organisms to indicator chemicals from the Site. As with the other engineering containment process options for dredged sediments, on-site upland containment would not reduce the toxicity or volume of these sediments. However, a properly engineered containment structure would prevent the migration of contaminated sediments from the Site.

Implementability
This process option could be implemented using conventional earthmoving equipment and standard construction methods, in accordance with U.S. Army Corps of Engineers and BCDC requirements and/or guidance. Since the dredged sediments are not considered to be a RCRA waste, the RCRA minimum technology requirements would not be ARARs for this process option.

The upland containment of dredged sediments would require significant areas for proper conditioning and disposal. Use of a clamshell dredge would be preferred over a hydraulic dredge, since the former method would yield sediments with a much higher solids content. Nevertheless, there is relatively little area available for on-site upland containment, limiting the implementability of this process option.

The grade over much of the Site could not be significantly altered due to the presence of several rail lines, the train scale, and the large pile-supported wharf which LRTC actively uses for its terminal operations. Therefore, ponding basins or diked impoundments would need to be constructed between the rail lines or in areas of the Site which are not actively used for terminal operations.

Additionally, it would be preferable to dispose of dredged sediments in upland areas of the Site near the former United Heckathorn facility, since this area has already been impacted by the indicator chemicals. Disposal of the dredged sediments at the southern part of the Site would not only be incompatible with existing terminal operations, but would increase the area of contamination at the Site.

Cost

The on-site containment of dredged sediments would be moderately expensive to implement compared to other disposal alternatives. Assuming that Lauritzen Canal sediments were contained near the former United Heckathorn facility, it would be more cost effective to deposit this material in diked areas, rather than excavated ponds, to avoid the costs for disposing of excavated soils as hazardous wastes.

Costs for this process option would be significantly increased if it were necessary to treat return water generated by drying the sediments. Costs would be further increased if the on-site containment of dredged materials interfered with LRTC's ongoing and future shipping operations at the Site.

Overall Evaluation

The on-site upland containment process option would effectively contain dredged sediments, but would be difficult to implement because of the limited area available at the Site. Depending on the location and areal extent of the containment facility, the costs for upland disposal of dredged sediments would be moderate to very expensive. Since BCDC and U.S. Army Corps of Engineers requirements specify that bay filling be minimized, the upland disposal option has been retained for further consideration in the development of remedial alternatives for the Site.

### 3.5.7 REMEDIAL TECHNOLOGY: OFF-SITE DISPOSAL

#### 3.5.7.1 Process Option: Ocean Disposal

This disposal option would involve barging the dredged sediments from the Lauritzen Canal to an ocean disposal site which has been permitted by the EPA in accordance with Section 102 of the Marine Protection, Research, and Sanctuaries Act of 1972 (MPRSA). The dredged material proposed for ocean disposal also would need to be permitted by the U.S. Army Corps of Engineers in accordance with Section 103 of the MPRSA. At present, EPA has not approved any ocean disposal sites in the Bay Area. The closest in-bay disposal site is near Alcatraz Island. However, there are stringent requirements for the disposal of sediments at the Alcatraz site. In particular, the dredged sediments must meet certain chemical and physical characteristics.

Effectiveness
This disposal option would reduce the volume of contaminated sediments from the Lauritzen Canal, but would not affect their toxicity. Ocean disposal would increase the mobility of these sediments by disposing of them in a more hydrodynamic environment where they could become further dispersed in the marine environment.

Implementability
Ocean disposal could be accomplished using tugs and barges which are available in the San Francisco Bay Area. However, the Lauritzen Canal sediments have chemical or physical characteristics which probably would make this material ineligible for ocean disposal. For example, 40 CFR Section 227.6 prohibits the ocean dumping of materials containing organohalogen compounds as other than trace contaminants. These regulations further prohibit the ocean disposal of materials which have the possibility to bioaccumulate in marine organisms. Since previous testing results have detected elevated concentrations of chlorinated pesticides in the Lauritzen Canal sediments and biota, the ocean disposal of these sediments would not be an acceptable alternative.

Cost
The cost for ocean disposal would be low compared to other disposal options.

Overall Evaluation
Ocean disposal would not reduce the toxicity of the offshore sediments, and would probably increase their mobility. Given the likelihood that these sediments would not meet the

regulatory requirements for ocean dumping, this process option has been screened from further consideration in this FS Report.

3.5.7.2 Process Option: Off-Site Disposal Along Parr Canal

Levin Enterprises, Inc., LRTC's parent company, owns a tract of land adjacent to the Parr Canal, located approximately 0.25 mile due east of the Site. This process option evaluates the possibility of disposing contaminated sediments dredged from the Lauritzen Canal at this off-site location. The Parr Canal property consists of a U-shaped area of approximately 9.5 acres, which surrounds the Parr Canal on three sides. This property is undeveloped except for several small wood-frame buildings which are currently unused.

The Parr Canal property reportedly was used by previous site occupants for the disposal of sediments dredged from the Lauritzen Canal. Previous sampling results have documented DDT concentrations up to 399 ppm in soils at the Parr Canal property (HLA, 1985). Under DHS oversight, LRTC has already completed a site investigation and has capped affected soils at the Parr Canal property (HLA, 1989).

Additional sediments from the Lauritzen Canal potentially could be disposed of at this off-site property. These sediments could be hydraulically dredged and pumped as a slurry into one or more settling basins which would be constructed along the east and/or west sides of Parr Canal. This option would not involve filling the Parr Canal waterway. After dewatering, the upland pond(s) could be covered with a clay and asphalt cap.

Effectiveness
Upland disposal at the Parr Canal property would not reduce the toxicity or volume of contaminants. However, these sediments would be transferred from the Lauritzen Canal to an upland location, eliminating the potential for contaminant exposures to the estuarine biota. There would be some short-term environmental risks if sediments were accidentally discharged during the transport operation (e.g., due to pipeline leaks or breakage). However, since the pipeline would be tested for leakage prior to use, and would be monitored during the transport operation, the risks of an accidental discharge are believed to be low.

Implementability
This process option would be implementable using conventional dredging, excavation, and solids handling methods. The amount

of sediments which could be disposed at the Parr Canal property would depend, in part, on Levin Enterprises' plans for future development of this property. Disposal of offshore sediments in this manner would not involve filling bay water, and therefore might be favored by the BCDC. However, LRTC would need to obtain a hazardous waste disposal facility permit from DHS for the future placement of Lauritzen Canal sediments at this off-site location. It could take several years for the involved agencies to review and process the application(s) for a new land disposal facility. Given the difficulties in siting and approving new land disposal facilities, LRTC's application ultimately might not be approved.

Cost
The costs for upland disposal of Lauritzen Canal sediments at the Parr Canal property would depend on several factors. The costs to transport dredged sediments to this location, and to dispose of them in unlined ponds, would be relatively low compared to other disposal options. However, additional costs would be incurred to obtain a hazardous waste disposal facility permit. The cost of this disposal option would be further increased if sediments needed to be treated (e.g., fixed with cement) prior to disposal.

Overall Evaluation
Because of the requirement to obtain a hazardous waste land disposal facility permit for the Parr Canal property, and the institutional problems associated with this permitting requirement, this process option has been screened from further consideration as part of the FS Report.

3.5.7.3 Process Option: Off-Site Disposal in Graving Dock

This process option would involve the disposal of dredged sediments in an existing graving dock owned by the Port of Richmond. The Port of Richmond owns five graving docks at Point Potrero, approximately 1.25 miles south of the Site. Each graving dock is lined with concrete, and ranges from 587 to 750 feet long, 100 feet wide, and 36 to 48 feet deep. These structures were constructed for use as dry dock facilities, with watertight gates opening onto the Richmond Harbor Channel. Ships requiring maintenance or repairs could enter one of the graving docks. After closing the gates, water could be pumped out to create a dry working area. After completing repair work, the dock would again be flooded, so the ship could exit the facility. These docks are currently open to bay waters.

Based on preliminary discussions with the Port of Richmond, the Port might consider filling in one or more of these graving docks, since they are too small for use with modern cargo ships. If an agreement could be arranged between LRTC and the Port of Richmond, sediments from the Lauritzen Canal could be barged to Point Potrero, where they would be unloaded and disposed in a graving dock. Afterwards, the dredged sediments would be covered with clean fill and capped with asphalt or other suitable pavement.

Effectiveness

Disposal of the Lauritzen Canal sediments in a graving dock would effectively contain these sediments but would not reduce their toxicity or volume. There would be some short-term risks during the dredging and transport of sediments to this off-site location. However, these risks would be controlled by using appropriate dredging methods, and by close monitoring of transport and disposal operations.

Before this disposal option could be implemented, the graving dock would need to be inspected for potential structural problems. Cracks, leaks, and other maintenance problems would need to be addressed before the dock could be used by LRTC. The gates would be reinforced, if necessary, and permanently sealed before dredged sediments were disposed at this location.

Implementability

There could be potential problems in implementing this disposal option. Assuming that LRTC and the Port of Richmond could reach an agreement for use of the graving dock, it would be necessary to obtain applicable permits from DHS and oversight agencies for the disposal of Lauritzen Canal sediments at this off-site location. The permit applications could involve a very lengthy review and approval process. Given the difficulties in siting and approving new hazardous waste disposal facilities, and the graving dock's close proximity to the Bay, it could be very difficult to obtain regulatory approval for this process option.

Cost

The costs to dispose of Lauritzen Canal sediments in one of the Port of Richmond's graving docks would be low to moderate, compared to other disposal options. Costs could be much higher if significant repairs or retrofitting were required to prepare the facility for disposal of the sediments. Additional costs might be significant to obtain applicable permits.

Overall Evaluation
There could be significant institutional problems associated with this disposal option. Since LRTC does not own the graving dock, it would be necessary to work out an agreement with the Port of Richmond to use this facility. It would also be necessary to obtain various permits prior to placement of the Lauritzen Canal sediments in one of the graving docks. Given the difficulties of obtaining the above agreements and/or permits, this process option has been screened from further consideration.

#### 3.5.7.4 Process Option: Off-Site Disposal at Existing Hazardous Waste Landfill

With this process option, contaminated sediments from the Lauritzen Canal would be disposed at an existing permitted hazardous waste landfill. After dredging, the sediments would need to be dewatered and might require further treatment (e.g., fixation with portland cement or other agent) prior to off-site disposal. The conditioned sediments would be loaded into trucks or rail cars for transportation to the off-site facility.

Effectiveness
Off-site disposal of the Lauritzen Canal sediments would not reduce their toxicity or volume. However, these sediments would be transferred from the Lauritzen Canal to an upland location, eliminating the potential for contaminant exposures to the estuarine biota. There would be some short-term environmental risks if sediments were released during the transport operation (e.g., due to truck or train accidents).

Implementability
This process option would be implementable using conventional dredging, excavation, and solids handling methods. However, given the limited on-site area which is available for sediment processing, the cleanup of Lauritzen Canal sediments would need to be conducted in phases, and could require several years to complete.

Disposal of offshore sediments in this manner would not involve filling bay area, and therefore would not need to be approved by the BCDC.

Cost
The costs for off-site disposal of Lauritzen Canal sediments at an approved hazardous waste facility would be very high. These costs include the conditioning of dredged sediments, transportation expenses, and fees for off-site disposal.

Overall Evaluation
Off-site disposal of dredged sediments would effectively reduce the volume of hazardous wastes in the Lauritzen Canal by transporting them to a more secure permitted location. Although this process option would be very costly, it would not require additional permits from BCDC, DHS, or EPA. To provide a broad range of possible cleanup alternatives, this process option has been retained for further consideration in this FS Report.

3.5.8 REMEDIAL TECHNOLOGY: PHYSICAL TREATMENT

3.5.8.1 Process Option: Sediment Extraction

This treatment option would be similar to that previously described for upland area soils (see Section 3.3.7.1). The presence of silt and clay-sized particles would make it very difficult to adequately separate solid and liquid phases. Additionally, the sediments would need to be conditioned to lower the moisture content to an acceptable concentration prior to extraction with an organic phase. This pretreatment step would generate large quantities of wastewater which might require additional treatment.

As previously noted, soil extraction has not been demonstrated to be an effective process option for soils contaminated with chlorinated pesticide wastes. The effectiveness of this treatment process with offshore sediments is also unproven. Moreover, the high water content and small particle size of these sediments would increase the difficulty of using an extraction process. Given these factors, as well as the limited availability of companies able to perform this process, and the expected high costs for treatment, sediment extraction has been screened out as an option for cleaning up offshore sediments at the Site.

3.5.8.2 Process Option: Fixation

This treatment option would be similar to that previously described for upland area soils (see Section 3.3.7.3). However, in situ fixation would not be appropriate for offshore sediments. Instead, this process would be implemented as a batch treatment process with dredged sediments. As with the upland soils, fixation would not be necessary to reduce the leachability of the indicator chemicals, which already have very low solubilities and high soil adsorption coefficients. However, fixation would be an effective method to condition dredged sediments for disposal at an on-site or off-site location. Cement or other additives could be mixed with the sediments to absorb water and improve solids handling characteristics. This process would increase the volume and cost of offshore sediment disposal, but could significantly shorten cleanup times for this medium. Therefore, this process option has been retained for further consideration for remediating the Lauritzen Canal offshore sediments.

### 3.5.9 REMEDIAL TECHNOLOGY: CHEMICAL TREATMENT

#### 3.5.9.1 Process Option: Dechlorination

This process option would be similar to that previously described for upland soils (see Section 3.3.8.1). However, the high moisture content and salt concentration of offshore sediments would significantly reduce the effectiveness of this treatment process. As with soils, the moisture content would need to be reduced to 0.2 percent or less prior to treatment. This step would require substantial dewatering to pretreat the sediments. Sediment may need to be washed before they are dewatered, to remove salts, since the presence of chloride ions may reduce dechlorination efficiency of the treatment process.

Dechlorination has not been demonstrated to be an effective or readily implementable process option for treating soils containing chlorinated pesticides. The additional factors noted above would make the effectiveness of this method even more uncertain for use with offshore sediments. Therefore, dechlorination has been screened out as a process option for treating embankment sediments at the Site.

### 3.5.10 REMEDIAL TECHNOLOGY: THERMAL TREATMENT

#### 3.5.10.1 Process Option: Incineration

This thermal treatment process would be as previously described for upland soils (see Section 3.3.9.1). As with upland soils, incineration would be effective in reducing the volume and toxicity of contaminated offshore sediments. However, it would be very costly to treat these sediments by incineration due to the dewatering, transportation, and energy requirements for this process. Additionally, since very limited incineration capacity is currently available for contaminated soil and debris, there may be significant delays in treating embankment sediments by this method. Therefore, the incineration process option has been screened from further consideration in this FS Report.

3.5.10.2 Process Option: Vitrification

This thermal treatment process would be as previously described for upland soils (see Section 3.3.9.2). As with upland soils, the vitrification process has been screened out in this FS, due to its unproven effectiveness, limited availability, and very high cost to implement.

## 3.6 Representative Process Option Summary

The preceding discussions in this section have identified and evaluated a wide range of process options using the criteria of effectiveness, implementability, and cost. In accordance with the NCP and EPA's RI/FS guidance document, those process options which do not meet the above criteria have been screened from further consideration as part of this FS Report.

Table 3-10 summarizes the process options which have been retained for upland soils, embankment sediments, and Lauritzen Canal sediments. These options include various institutional actions (site-use restrictions and monitoring), removal methods (excavation and dredging), engineering controls to contain soils and sediments (upland and in-bay structures), treatment methods (fixation and incineration), and off-site land disposal of affected materials. In Section 4.0 of this FS Report, the process options which have been retained are combined into various remedial alternatives which are designed to protect human health and the environment.

## 4.0 DEVELOPMENT AND ANALYSIS OF ALTERNATIVES

### 4.1 Development of Remedial Alternatives

This section combines the various treatment, containment, removal, disposal, and monitoring process options described and evaluated in Section 3.3 into several remedial alternatives which meet the remedial action objectives for the United Heckathorn Site. Engineering judgment was used in assembling general responses for various areas and media at the Site to provide compatible combinations which satisfy the remedial action objectives. In accordance with the NCP and EPA's RI/FS guidance document, several alternatives have been developed to provide decision makers with a range of options and sufficient information to adequately compare alternatives.

As stated in the NCP (40 CFR 300.430), EPA's general approach to developing appropriate remedial alternatives is to use treatment to address principal threats posed by a site, wherever practicable. For example, treatment would be favored for hazardous wastes that are liquids, highly toxic, or highly mobile. However, EPA expects to use engineering controls, such as containment, for wastes that pose a relatively low long-term threat or where treatment is impractical. Where appropriate, a combination of treatment and containment methods may be used to achieve protection of human health and the environment. EPA also recommends the use of institutional controls such as water-use and deed restrictions to supplement engineering controls for short- and long-term management to prevent or limit exposure to hazardous substances at a site.

Consistent with the above EPA approach, the range of alternatives for the Site include various containment methods and institutional controls designed to protect human health and the environment by preventing potential exposure and/or reducing the mobility of contaminants; and the off-site treatment/disposal of highly contaminated soils and sediments to reduce their toxicity, mobility, and volume. Additionally, the "no action" alternative has been retained as a baseline for comparison with the other alternatives.

The environmental media requiring remediation at the Site include upland soils, embankment sediments, and offshore sediments in the Lauritzen Canal. The cleanup of these source areas will significantly reduce the potential for contaminant release to ambient air, ground water, and surface water, lowering human health and environmental risks to health-protective levels. The principal differences between these alternatives consist of the amount of contaminated soil and sediments transported off-site for treatment/disposal, and the manner in which dredged sediments from the Lauritzen Canal are contained on site. The specific remedial alternatives developed for the Site are described in Section 4.2 and are highlighted below:

Alternative 1: "No action."

Alternative 2: On-site containment of chemical-affected soils; on-site containment of dredged sediments behind a sheet pile bulkhead.

Alternative 3: Same components as Alternative 2, except that dredged sediments would also be contained behind a rock dam.

Alternative 4: Same components as Alternative 3, except that dredged sediments would also be contained in an on-site upland disposal unit.

Alternative 5: Off-site treatment and disposal of soils with relatively high pesticide concentrations; capping upland area; shoreline stabilization with sheet pile bulkhead; off-site disposal of dredged sediments at a permitted facility.

With the exception of the "no action" alternative, all of the above alternatives have been developed to meet the remedial action objectives. In addition to the components listed above, each alternative includes environmental monitoring to evaluate the effectiveness of future cleanup measures and various institutional controls to maintain future exposure risks at an acceptably low level.

## 4.2 Detailed Analysis of Alternatives

### 4.2.1 INTRODUCTION

The detailed analysis of alternatives consists of the following three steps: further definition of each alternative with respect to the areas of affected media addressed, the technologies used, and any performance requirements associated with these technologies; an assessment and a summary profile of each alternative with respect to the evaluation criteria; and a comparative analysis of the alternatives to assess the relative performance of each alternative with respect to the evaluation criteria.

EPA has developed nine evaluation criteria to address the CERCLA requirements and considerations listed above, and to address the additional technical and policy considerations that have proven to be important for selecting among remedial alternatives. These evaluation criteria serve as the basis for conducting the detailed analyses and for subsequently selecting an appropriate remedial action.

The nine CERCLA evaluation criteria are described below:

- Short-Term Effectiveness
  The assessment using this criterion examines the effectiveness of alternatives in protecting human health and the environment during the construction and implementation of a remedy until remedial action objectives have been met.

- Long-Term Effectiveness and Permanence
  The assessment using this criterion evaluates the long-term effectiveness of alternatives in maintaining protection of human health and the environment after remedial action objectives have been met.

- Reduction of Toxicity, Mobility, and Volume Through Treatment
  The assessment using this criterion evaluates the anticipated performance of the specific treatment technologies with respect to reductions in chemical toxicity, mobility and volume, including the type and quantity of residuals and the degree to which treatment reduces risk at the Site.

- Implementability
  The assessment using this criterion evaluates the technical and administrative feasibility of alternatives and the availability of required goods and services.

- Cost
  The assessment using this criterion evaluates the capital and operation and maintenance (O&M) costs associated with each alternative.

- Compliance with ARARs
  The assessment using this criterion describes how the alternative complies with ARARs, or, if a waiver is required, how it may be justified.

- Overall Protection of Human Health and the Environment
  The assessment using this criterion describes how the alternative as a whole would achieve and maintain protection of human health and the environment, in both the short and long terms, from unacceptable risks posed by hazardous substances. Only those alternatives determined to be protective would be further considered in the selection of a final cleanup plan for the Site.

- State Agency Acceptance
  The assessment using this criterion will reflect the State agencies' apparent preferences among, or concerns about, alternatives. This criterion will be addressed by EPA during preparation of the Record of Decision (ROD), after comments on the RI/FS Report and Proposed Plan have been received.

- Community Acceptance
  The assessment using this criterion will reflect the community's apparent preferences among, or concerns about, alternatives. As with the State Agency Acceptance criterion, Community Acceptance of the alternatives will be addressed by EPA during preparation of the ROD, after comments on the RI/FS Report and Proposed Plan have been received.

The following sections provide detailed analyses of the remedial alternatives identified for the Site. These alternatives are analyzed according to the specific CERCLA criteria detailed above. The results of this evaluation, which compares the alternatives and identifies some of the differences between them, are discussed in Section 4.3.

### 4.2.2 ALTERNATIVE 1

#### 4.2.2.1 Description

Alternative 1, the "no action" alternative, is included as required by the NCP and SARA, to provide a baseline from which to analyze and assess other alternatives. Alternative 1 does not include any remedial activities to reduce the toxicity, volume, or mobility of hazardous wastes at the Site. However, various institutional measures could be undertaken to protect human health. These activities include the maintenance of existing access control measures (fencing and warning signs), deed restrictions to control future land uses, and continued environmental monitoring. Environmental monitoring could include visual inspections of the embankment area for signs of erosion, and periodic chemical analyses of air, surface water, ground-water, and biota samples.

4.2.2.2 Alternative 1 Assessment

Short-Term Effectiveness
This criterion addresses the alternative's ability to protect human health and the environment while remedial activities are being implemented. However, since no remedial activities would be implemented under Alternative 1, the potential risks from the Site would remain unchanged from current conditions.

Long-Term Effectiveness and Permanence
As previously noted, the "no action" alternative would not reduce the concentrations or mobility of chemical-affected soils and sediments at the Site. Therefore, the potential human health and environmental risks at the Site are assumed to remain constant over time.

The PHE indicates that there currently are no significant adverse human health effects due to exposure to indicator chemicals at the Site. Therefore, so long as conditions do not change, the "no action" alternative would be effective for protection of human health. However, previous chemical analyses have documented significantly elevated indicator chemical concentrations in Lauritzen Canal sediments and aquatic organisms. Because the "no action" alternative would allow the continued exposure of estuarine species to elevated concentrations of DDT and other pesticides, this alternative would not provide an acceptable permanent remedy. Moreover, if soils and sediments are not properly remediated, then the indicator chemicals could migrate further from source areas at the Site.

Reduction of Toxicity, Mobility, or Volume Through Treatment
The "no action" alternative would not reduce the toxicity, mobility, or volume of chemical-affected soils and sediments at the Site. The chlorinated pesticide indicator chemicals are relatively stable compounds, with high soil adsorption coefficients and low biodegradabilities. Therefore, natural attenuation processes alone (e.g., dilution and biodegradation) would require an excessively long time to significantly reduce indicator chemical concentrations.

Implementability
If found to be acceptable, the "no action" alternative could be implemented. Implementation would consist primarily of the institutional actions taken to restrict and/or monitor potential future exposures to chemicals at the Site.

Cost
The estimated capital costs associated with this alternative include the installation of new monitoring wells and air monitoring stations. Operation and monitoring costs include annual site inspections and environmental monitoring (ground-water, air, offshore sediments, and biological samples). The total present worth cost for this alternative is estimated to be approximately $ 1.25 million (see Table 4-1).

Compliance with ARARs
Based on existing conditions at the Site, the "no action" alternative would be expected to meet ARARs.

Overall Protection of Human Health and the Environment
With appropriate land and water-use restrictions to maintain current site conditions, the "no action" alternative would be expected to be protective of human health. However, the "no action" alternative would not be protective of the environment. Under existing conditions, Lauritzen Canal sediments contain significantly elevated pesticide concentrations, and the available data indicate the potential for estuarine organisms to bioconcentrate these chemicals. Portions of the Lauritzen Canal embankment contain significantly elevated pesticide concentrations. If not removed or contained, these shoreline sediments could migrate into the Lauritzen Canal waterway, where they would be subject to further dispersal in the environment.

State Agency and Community Acceptance
Documentation of State agency and community acceptance of this alternative would be provided after the appropriate review process has been completed.

4.2.3 ALTERNATIVE 2

4.2.3.1 Description

This alternative uses a combination of engineering containment options to remediate hazardous wastes at the Site. The major components of this alternative are as follows:

- on-site containment of chemical-affected upland soils and embankment sediments
- on-site containment of dredged sediments behind a sheet pile bulkhead
- institutional controls (i.e., site use restrictions and environmental monitoring).

Each of the above components are described in detail below.

A. <u>On-Site Containment of Chemical-Affected Upland Soils</u>

Under Alternative 2, chemical-affected upland soils would be capped in place using asphalt concrete and a geotextile fabric. As shown in Figure 4-2, the proposed area to be capped would extend from the northern property boundary (near Cutting Boulevard) southward to near the existing railroad hopper building. This area includes approximately 1,000 cubic yards of soil which have been piled near the northeastern corner of the Site. These soils would be graded and compacted before they are capped.

B. <u>On-Site Containment of Embankment and Offshore Sediments Behind a Sheet Pile Bulkhead</u>

Embankment sediments along the shoreline would be contained in place behind a steel sheet pile bulkhead. This bulkhead would be constructed along the eastern shoreline of the Lauritzen Canal, outboard of the existing pile-supported wharf (see Figure 4-2). These affected shoreline sediments would be further contained by the placement of dredged sediments behind the sheet pile bulkhead, as noted below.

Lauritzen Canal offshore sediments with a total chlorinated pesticide concentration greater than 0.2 ppm are targeted for remediation. These offshore sediments would be dredged from the affected areas of the canal bottom, and contained behind this sheet pile bulkhead. The average total chlorinated pesticide concentration of these sediments is estimated to be less than 100 ppm, consisting primarily of DDT, DDD, and DDE.

The proposed depths to be dredged are shown in Figure 4-2. These depths range from approximately 8 feet below the mudline, near the head of the canal, to approximately 2 feet deep, near the mouth of the canal. The insitu volume of sediment to be dredged would be approximately 42,000 cubic yards. Using a bulking factor of 0.15, a total volume of approximately 48,000 cubic yards of sediment would be placed behind the bulkhead. Since most of these bottom sediments consist of a soft silty clay, a suction dredge could be used to remove these sediments. This type of dredge can be operated to generate relatively little turbidity, and the dredged slurry could be pumped to the on-site containment area under the wharf.

The proposed sheet pile wall would be driven along the toe of the eastern shoreline of the Lauritzen Canal and anchored to the slope using a tieback system. Construction of the sheet pile wall would include driving steel sheets to the required embedment depth, backing the sheets with a geotextile layer, driving batter H-piles (anchorage), installing wales, tie rods, and supports, and casting concrete caps on the top of the wall. Once construction of the bulkhead has been completed, dredged sediments would be placed behind it and appropriately capped. A cross section of the proposed wall adjacent to the existing dock is shown on Figure 4-3, and a detail of that anchorage system is shown on Figure 4-4. A cross section of the bulkhead north of the existing dock is shown on Figure 4-5.

One consideration regarding steel sheet piling is corrosion. Several forms of corrosion protection have been used and tested by government agencies and private industry. Based on literature from the U.S. Army Corps of Engineers and the National Bureau of Standards, a combination cathodic protection and coating of the piling would appear to be optimal. Cathodic protection has proven effective in the immersed section of piling used on other local projects. The section not fully submerged (the splash zone) would be protected in part by a coating. The coating selected would be based on information from other local projects, and on environmental factors such as pH, resistivity, or the presence of chlorides or sulfides in the soil. For the purposes of this FS Report, a coal tar epoxy coating was assumed. To further protect the section of piling in the splash zone, a concrete cap to encase the piling is proposed. This cap would fit tightly around the steel sheet piling, minimizing or eliminating contact of canal water and the steel.

A second consideration regarding steel sheet piling is sediment seepage. Fine sediments could potentially seep through the interlocks and weep holes of the sheet pile bulkhead. Therefore, a geotextile backing would be installed to control sediment migration. This geotextile would act as a filter against the back (inboard) side of the sheet piling, to reduce the migration of sediments through the sheet piling.

This cleanup measure would reduce the surface area of the Lauritzen Canal by approximately 1.8 acres but would not reduce the volume of bay waters subject to tidal action. Most of the dredged sediments would be placed underneath the existing pile-supported wharf and along the shoreline area containing abandoned pilings from the former dock. The presence of these structures already significantly limits the existing habitat value within this part of the Lauritzen Canal.

C. Institutional Controls (i.e., Site Use Restrictions and Environmental Monitoring)

Institutional controls would be implemented to significantly limit or prevent potential exposures to hazardous substances remaining at the Site after the preceding containment, treatment, and disposal actions are completed. These institutional actions include the following process options: environmental monitoring, access control measures, deed restrictions, and water-use restrictions.

Environmental monitoring would be used to evaluate potential short-term exposures during site cleanup as well as long-term risks after remedial measures are completed. These monitoring activities include visual inspections, sampling, and chemical analyses. Visual inspections would be used to evaluate the condition of remedial measures including caps, drainage control structures, and the sheet pile bulkhead. Chemical analyses would be performed on samples of ground water, surface water, benthic sediments, and estuarine organisms (e.g., shellfish). Sampling results would be used to evaluate the effectiveness of the completed remedial actions at the Site.

The access control measures currently in place, including warning signs and a 6-foot-high chain-link fence which is topped with barbed wire, would be maintained. The proposed sheet pile bulkhead along the embankment would provide an effective access barrier to the upland part of the Site from the Lauritzen Canal waterway.

Since the Lauritzen Canal is designated and operated as a shipping channel, without boat ramps or other public shoreline facilities, further public access restrictions are believed to be unnecessary. Notwithstanding the heavy industrial marine use of this waterway, warning signs have been posted along the pile-supported wharf at the Site to advise people that canal sediments, fish, and shellfish may be contaminated with DDT. These signs would be maintained as part of the remedial action plan.

Deed restrictions would be applied to chemical-affected areas to reduce the potential for future exposures to upland soils at the Site. Such restrictions would identify the specific areas where hazardous wastes are located, and require that appropriate safeguards be undertaken to prevent exposure to contaminants during future excavation or development of the Site. Additionally, deed restrictions could be filed so that future land owners would use the Site in a manner that is consistent with the Site's current municipal zoning classification for heavy industrial activities (M-3).

#### 4.2.3.2 Alternative 2 Assessment

Short-Term Effectiveness

This criterion addresses the potential human health and environmental risks associated with implementation of remedial activities under Alternative 2. These activities include the on-site containment of chemical-affected upland soils and embankment sediments; and the dredging and containment of offshore sediments, as discussed below. The entire remediation phase could be completed in approximately one year.

The dredging of offshore sediments could create potential short-term environmental risks due to increased turbidity of Lauritzen Canal waters. However, proper dredging techniques would reduce these risks. For example, the use of low-turbidity dredge vessels, equipment, and techniques would reduce the amount of sediment resuspension beyond the immediate vicinity of the dredge. The amount of sediment resuspension can be further reduced by proper selection of ladderswing speeds and depth of cut. Dredging would not be conducted when inclement weather might cause significant suspension of sediments. Thus, short-term environmental risks associated with dredging should be effectively managed using appropriate dredging equipment and methods as noted above.

The turbidity of dredge return water can be controlled through the design of appropriate discharge structures. For example, geotextiles have been used in similar dredging projects to reduce sediment return flows to less than 0.1 mg/liter/hour.

Long-Term Effectiveness and Permanence
After remediation is completed, the potential for long-term adverse health or environmental effects due to exposure to indicator chemicals at the Site would be very low. Alternative 2 employs proven technologies for remediating chemical-affected soils and sediments.

Upland soils and sediments would be capped in place. Dredged sediments would be placed behind an engineered sheet pile bulkhead, designed to resist corrosion and seismic forces. These structures could be designed and maintained to provide long-term effectiveness. Periodic monitoring would be combined with routine operation and maintenance procedures to confirm that wastes are adequately contained at the Site.

With adequate materials and proper construction of the anchorage, concrete capping of the upper portion of the wall and proper installation of a geotextile backing, the steel sheet pile bulkhead should maintain its integrity for the duration of its design life. Based on other local projects which have utilized similar materials for sheet pile walls and bulkheads, it is reasonable to assume that the design life of the proposed bulkhead structure may exceed 100 years. Performance data on geotextiles is not available for that amount of time; however, there is no reason to believe geotextiles will not perform adequately for such a design life, so long as they are protected from sunlight.

Reduction of Toxicity, Mobility, or Volume Through Treatment
Under Alternative 2, chemical-affected soils and sediments would be remediated by containment methods.

Although engineering containment would not reduce the volume or toxicity of chemical-affected soils and sediments, the proposed remediation measures would still be protective of human health and the environment. Given the very low solubilities and very high soil adsorption coefficients of site contaminants, these chemicals would be expected to remain adsorbed to soil and sediment particles. The physical containment actions proposed under Alternative 2 should effectively immobilize these particles, significantly reducing the potential for future releases and/or exposures to affected materials at the Site.

Implementability
The engineering containment options proposed as part of this alternative would be implementable using standard equipment and construction materials. Since the Site is an active marine shipping terminal, remedial activities would need to be

coordinated with LRTC's facility operations to reduce the amount of business interruptions resulting from dredging, excavation, and related construction work.

The proposed containment of dredged sediments behind a sheet pile bulkhead would require approval by several state and federal agencies, including BCDC, the U.S. Army Corps of Engineers, and EPA. Although permits may not be required from these agencies (see Section 2.2.3), it would still be necessary to comply with all of the substantive requirements of these agencies.

Cost

The estimated present worth cost for Alternative 2 is $ 12.0 million. A detailed breakdown of the capital and O&M costs for this alternative is presented in Table 4-2. The capital costs include grading, capping, dredging, construction of the proposed sheet pile bulkhead, and related monitoring activities. These costs assume that offshore sediments would be dredged hydraulically and dredge return water would not require significant treatment.

Operation and maintenance costs include periodic inspections and environmental monitoring. The costs of environmental monitoring process options would be highly dependent on the type, frequency, and length of time such monitoring would be required. For relatively short monitoring periods (such as during soil excavation), costs would be low to moderate. For long-term monitoring, the costs would be relatively high. In calculating present worth costs, a monitoring period of 30 years has been assumed.

Table 4-2 includes cost estimates for several other activities related to site remediation, including the removal and reconstruction of the pile-supported rail lines, wharf, and rail cranes. It should be noted that significant additional costs may be incurred if mitigation (e.g., creation of wetland habitat) is required for the on-site containment of dredged sediments. These costs have not yet been estimated, since they would depend on the specific mitigation requirements which the involved regulatory agencies would identify for Alternative 2. Additionally, LRTC could incur significant costs due to business interruptions during the remedial construction phase.

Compliance with ARARs

The proposed remedial actions under Alternative 2 would be expected to comply with the ARARs identified and discussed in Section 2.2.

Overall Protection of Human Health and the Environment
Alternative 2 would be expected to protect human health and the environment. Potential exposures to contaminated soils and sediments at the Site would be significantly reduced by a combination of containment and institutional actions, as summarized below.

The on-site containment of chemical-affected materials would significantly decrease the long-term potential for chlorinated pesticides to be released to surface water, ground water, and ambient air. These remedial measures would also reduce the potential for direct contact with hazardous wastes at the Site.

Potential environmental risks would be reduced by preventing contaminant migration from upland and embankment source areas, and by dredging affected offshore sediments. Containment of these offshore sediments behind a sheet pile bulkhead would significantly reduce potential future exposures to estuarine species. The proposed dredging, pile-driving, and related construction work would create short-term environmental risks to the extent that these activities generate turbidity in Lauritzen Canal waters. These short-term risks would be effectively controlled by using equipment and remediation procedures designed to reduce the resuspension of offshore sediments.

The long-term potential risks associated with residual contamination at the Site are expected to be very small. These potential risks would be further controlled by various institutional measures, including site security measures and land- and water-use restrictions. In addition, environmental monitoring would be used to confirm that remedial actions completed under Alternative 2 would remain protective of human health and the environment.

State Agency and Community Acceptance
Documentation of State agency and community acceptance of this alternative will be provided after the appropriate review process has been completed.

4.2.4 ALTERNATIVE 3

4.2.4.1 Description

As with Alternative 2, this alternative uses a combination of engineering containment options to remediate chemical-affected materials at the Site.

Under Alternative 3, the most highly affected offshore sediments would not need to be dredged. Instead, these sediments would be contained in place behind a combination sheet pile/rock dam to be constructed across the head of the Lauritzen Canal. Other remedial components to address contaminated upland soils and embankment sediments include the on-site containment of chemical-affected soils and sediments; and various institutional controls (i.e., environmental monitoring and site-use restrictions). These proposed cleanup activities for soils and embankment sediments would be essentially the same as those previously described for Alternative 2. The proposed measures to contain affected offshore sediments are described below.

Containment of Lauritzen Canal Offshore Sediments
In accordance with the proposed cleanup goal, Lauritzen Canal offshore sediments with total chlorinated pesticide concentrations greater than 0.2 ppm would be targeted for remediation. These sediments would be contained on-site behind a sheet pile/rock dam and a sheet pile bulkhead.

Under this alternative, offshore sediments with the highest pesticide concentrations (several hundred ppm or more) would not need to be dredged. Instead, these sediments would be contained in place behind the proposed sheet pile/rock dam and sheet pile bulkhead (see Figure 4-6). The area behind these containment structures would be backfilled with additional sediments dredged from other areas of the Lauritzen Canal and capped over to further contain these sediments. Construction of the dam and backfill would reduce the surface area of the Lauritzen Canal by approximately 2.6 acres.

The dam would consist of a vertical steel sheet pile wall with rock placed on the outboard side of the wall (see Figure 4-7). This structure would require significantly less fill than a conventional rock dam because of its smaller footprint within the canal. Moreover, the vertical inboard slope of the proposed rock/steel dam would create a greater storage capacity, allowing more dredged sediments to be contained behind this structure, compared to a dam constructed entirely of rock.

The outboard (i.e., rock) portion of the dam would have a 2H:1V slope. This assumed slope yielded a preliminary safety factor greater than 1.5 for both short-term and long-term static slope stability analyses. All analyses were performed using the computer slope stability program STABR. Details of the preliminary analysis are included in Appendix A.

Preliminary pseudostatic stability analyses were also performed to assess the dam's performance under seismic accelerations. Using a peak lateral ground acceleration of 0.3 g, the potential displacement of the rock dam was estimated to be approximately 2 to 30 centimeters. This range of displacement is believed to pose a minimal threat to the dam's stability.

Construction of the dam would include subexcavating the upper approximately 8 feet of sediments on each side of the proposed wall, placing a gravel subbase into this excavated area, driving the steel sheet pile wall across the canal, placing a geotextile backing on the inboard side of the wall to reduce the potential for migration of sediments, and placing graded gravel, sand, and rock on the outboard side of the wall concurrent with the placement of dredged sediments on the inboard side. Rock would initially be placed on the outboard side to approximately 10 feet above the foundation. As more rock was added, dredged sediments would be placed on the inboard side. This sequence would be followed until final grade was reached, keeping a maximum difference between outboard and inboard heights of 10 feet.

Construction of the proposed dam would require extending the existing 60-inch storm drain that currently discharges at the head of the Lauritzen Canal southward through the face of the dam. A pile-supported concrete outfall would be installed to extend this storm drain.

Dredged sediments would also be contained behind a steel sheet pile bulkhead constructed outboard of the existing pile-supported wharf. This structure would extend from the crest of the proposed dam southward for a distance of approximately 750 feet. This sheet pile wall would also be used to stabilize the shoreline and reduce the potential for erosion of embankment sediments. The same type of sheet pile, tie-back system, and corrosion protection measures as previously described for Alternative 2 would be used.

The proposed depths to be dredged are shown in Figure 4-6. These depths range from approximately 5 feet below the mudline, near the toe of the dam to approximately 2 feet deep, near the mouth of the canal. Under Alternative 3, the total volume of sediment to be dredged is estimated to be approximately 33,000 cubic yards (in situ volume). Assuming a bulking factor of 0.15, a total volume of 38,000 cubic yards of sediment would be placed behind the dam and bulkhead.

Institutional Controls (i.e., Site Use Restrictions and Environmental Monitoring)
Various institutional actions, including environmental monitoring, access control measures, deed restrictions, and water-use restrictions, would be implemented along with the above remedial components. These institutional actions would be essentially the same as those previously described for Alternative 2.

4.2.4.2 Alternative 3 Assessment

Short-Term Effectiveness
The short-term risks associated with the excavation, handling, and transportation of upland soils and embankment sediments would be the same as those previously described for Alternative 2. The entire remediation phase could be completed in approximately one year.

Construction of the sheet pile/rock dam could create some turbidity. However, compared to Alternative 2, there would be less potential for resuspension and migration of offshore sediments, since a smaller volume of sediments would need to be dredged, and the most affected sediments would be contained in place behind the dam and bulkhead structures.

Long-Term Effectiveness and Permanence
As with Alternative 2, the upland soils and embankment sediments would be remediated by a combination of response actions which have been proven to be effective. The offshore sediments with the highest indicator chemical concentrations would be contained in place behind the steel sheet pile/rock dam and bulkhead and would be further encapsulated under approximately 15 feet of less contaminated sediments. If properly designed, constructed, and maintained, these containment structures would be expected to permanently immobilize the contaminated sediments.

Maintenance of the sheet pile/rock dam would include regular inspections of the structure to document the following: overall alignment; settlement of the crest, rock, or dredged sediments; outboard slope; and condition of the rock (angularity, size, interlocking between rocks, missing rocks, or rock slippage down slope). This inspection process would involve underwater inspection, including side scan sonar (conducted from a boat) and divers, to detect any irregularities in the underwater rock slope or toe of the structure. The condition of the cathodic protection system would also be checked to verify that it is fully operational.

Reduction of Toxicity, Mobility, or Volume Through Treatment
The toxicity, mobility, and volume of wastes at the Site would be reduced to a similar degree as previously described for Alternative 2.

Implementability
The proposed remedial activities for Alternative 3 could be implemented using standard equipment, materials, and construction methods, as previously described for Alternative 2. Conventional marine engineering methods would be used to construct the rock/sheet pile dam across Lauritzen Canal. Rock and sheet piles could be shipped by barge or rail to the Site. The dam would be constructed from the water. Piles could be driven using a barge-mounted rig. Rock and gravel could be placed using a bottom dump split hull barge and/or a large diameter pipe off the side of the barge.

The dredge and fill activities proposed for Alternative 3 would need to be coordinated with and/or approved by various State and federal agencies, including EPA, the U.S. Army Corps of Engineers, and BCDC. Additionally, it may be necessary to arrange agreements with other property owners along the Lauritzen Canal whose property would be affected by the proposed dam and backfilling.

Cost
The estimated present worth cost for Alternative 3 is $ 8.9 million. A detailed breakdown of the capital and O&M costs for this alternative is presented in Table 4-3. The capital costs include grading, capping, dredging, and construction of the proposed containment structures and related monitoring activities. These costs assume that offshore sediments would be dredged hydraulically and dredge return water would not require significant treatment.

Operation and maintenance costs include periodic inspections and environmental monitoring.

Table 4-3 includes cost estimates for several other activities related to site remediation, including the removal and reconstruction of the pile-supported rail lines, wharf, and rail cranes. Other costs would include LRTC's lost income due to business interruptions during the remedial construction phase. It should be noted that significant additional costs may also be incurred if mitigation (i.e., creation of wetland habitat) is required for the on-site containment of dredged sediments. Additional costs may also be required to relocate adjacent facilities which lose existing waterfront by the proposed filling activity. These costs have not yet been estimated, since they would depend on the specific mitigation requirements identified by the involved regulatory agencies and agreements reached with adjacent owners.

Compliance with ARARs

The proposed remedial actions under Alternative 3 would be expected to comply with the ARARs identified and discussed in Section 2.2.

Overall Protection of Human Health and the Environment

Alternative 3 would be expected to protect human health and the environment. Potential exposures to contaminated soils and sediments at the Site would be significantly reduced by a combination of containment and institutional actions, as previously discussed under Alternative 2. However, since less sediment would need to be dredged, and the most contaminated sediments would be contained in place, there would be a lower short-term risk during remediation. Moreover, the steel/rock dam would be a very permanent structure which would require relatively little maintenance over time.

State Agency and Community Acceptance

Documentation of State agency and community acceptance of this alternative will be provided after the appropriate review process has been completed.

### 4.2.5 ALTERNATIVE 4

#### 4.2.5.1 Description

As with Alternatives 2 and 3, this alternative uses a combination of engineering containment and treatment options to remediate hazardous wastes at the Site. However, Alternative 4 reduces the amount of fill in the Lauritzen Canal by containing some dredged sediments at an upland location at the northern part of the Site. Under this alternative, upland soils near the head of the Lauritzen Canal would be excavated to create additional storage capacity behind the proposed dam. This area would be backfilled with dredged material, which would be mounded to a height of several feet above the surrounding grade (see Figure 4-8). The dredging and containment of Lauritzen Canal sediments is described in further detail below.

Other remedial components of Alternative 4 include the on-site containment of chemical-affected soils and embankment sediments; and various institutional controls (i.e., environmental monitoring and site-use restrictions). These proposed cleanup activities would be essentially the same as previously described for Alternative 2.

<u>Containment of Lauritzen Canal Offshore Sediments</u>

Under Alternative 4, the affected offshore sediments would be contained behind a combination sheet pile/rock dam and sheet pile bulkhead constructed in the same manner as described for Alternative 3. However, the location of the dam would be shifted northward by approximately 260 feet, and the storage capacity behind the dam would be increased by excavating the upland soils north of the canal to a depth of approximately 20 feet below the existing grade.

The area behind the dam would be diked and backfilled with additional sediments dredged from other areas of the Lauritzen Canal. As these sediments become consolidated, the height of the diked area would be raised, and additional sediments would be deposited in this area. This process would result in an engineered fill approximately 4 feet higher than the surrounding upland grade at this part of the Site (see Figure 4-8). After the mounded sediments have become sufficiently consolidated, this area would be capped with asphalt concrete.

The time required to implement this alternative would depend largely on the rate at which dredged sediments could be dewatered and consolidated. Several steps could be used to speed up these processes. For example, a clamshell bucket could be used during dredging, to reduce the water content of the sediments. Clamshelled sediments initially could be dumped directly into the water behind the bulkhead. After the fill level is raised above sea level, the dredged sediments could be dried more quickly by constructing drainage trenches or installing wicks and surcharging the diked area before subsequent lifts of sediment are added to the fill. For this FS, it is estimated that the dredging and on-site containment process would require approximately one year to complete.

As with Alternatives 2 and 3, a steel sheet pile bulkhead would be constructed along the eastern shoreline of the Lauritzen Canal, outboard of the existing pile-supported wharf. This structure would stabilize the shoreline, reduce the potential for embankment sediments to erode into the canal, and provide additional capacity for the containment of dredged sediments.

The proposed depths to be dredged are shown in Figure 4-8. These depths range from approximately 8 feet below the mudline near the toe of the dam to approximately 2 feet deep near the mouth of the canal. Under Alternative 4, approximately 43,000 cubic yards of sediment would be dredged. Assuming a bulking factor of 0.15, a total volume of approximately 49,000 cubic yards of sediment would be placed behind the dam and sheet pile bulkhead at the Site.

The proposed excavation and fill activities would require an extensive effort to support or completely replace the existing 60-inch storm drain at the head of the Lauritzen Canal. If pipe support was the selected alternative, the pipe would need to be supported on pile foundation bents.

#### 4.2.5.2 Alternative 4 Assessment

Short-Term Effectiveness
The short-term risks associated with this alternative would be greater than those previously described for Alternatives 2 and 3. Alternative 4 would require significantly more excavation and handling of soils and sediments from the Site. There would be a potential risk of direct contact, ingestion, and inhalation of indicator chemicals by the heavy equipment operators involved in remedial activities. These risks would be reduced by adherence to an approved site health and safety plan.

Long-Term Effectiveness and Permanence
As with Alternatives 2 and 3, the affected soils and sediments would be remediated by a combination of response actions which have been proven to be effective. The engineered fill behind the proposed dam would require periodic monitoring and maintenance. As the underlying sediments gradually consolidate, the cap would be subject to differential settlement and cracking. These cracks could be repaired as part of the site maintenance program. The long-term effectiveness and permanence of the implemented cleanup activities would be confirmed through environmental monitoring, including analyses of ground water, surface water, offshore sediments and estuarine organisms.

Reduction of Toxicity, Mobility, or Volume through Treatment
The toxicity, mobility, and volume of wastes at the Site would be reduced to a similar degree as previously described for Alternatives 2 and 3.

Implementability
The proposed remedial activities for Alternative 4 could be implemented using standard equipment, materials, and construction methods, as previously described for Alternatives 2 and 3. Conventional construction methods would be used to excavate the upland pond, condition the dredged sediments, and build up the proposed dredge disposal site.

The dredge and fill activities proposed for Alternative 4 would need to be coordinated with and/or approved by various state and federal agencies, including EPA, the U.S. Army Corps of Engineers, and BCDC. Additionally, it may be necessary to arrange agreements with other property owners along the Lauritzen Canal whose property would be affected by the proposed dam and backfilling.

Cost
The estimated present worth cost for Alternative 4 is $ 12.0 million. A detailed breakdown of the capital and O&M costs for this alternative is presented in Table 4-4. The capital costs include soil and sediment excavation, off-site treatment and disposal, dredging, construction of the proposed containment structures, and extension of the existing 60-inch storm drain. These costs assume that dredge return water would not require significant treatment. These costs further assume that soils excavated to create additional storage capacity behind the dam could be disposed of as non-hazardous wastes.

Operation and maintenance costs include periodic inspections and environmental monitoring.

Table 4-4 includes cost estimates for several other activities related to site remediation, including the removal and reconstruction of the pile-supported rail lines, wharf, and rail cranes. The costs which LRTC would incur due to business interruptions during the remedial construction phase have not been included in this estimate. It should also be noted that significant additional costs may be incurred if mitigation (i.e., creation of wetland habitat) is required for the on-site containment of dredged sediments. Additional costs may also be required to relocate adjacent facilities which lose existing waterfront by the proposed filling activity. These costs have not yet been included in Table 4-4, since they would depend on the specific mitigation requirements or agreements reached for the Site.

Compliance with ARARs
The proposed remedial actions under Alternative 4 would be expected to comply with the ARARs identified and discussed in Section 2.2.

Overall Protection of Human Health and the Environment
Alternative 4 would be expected to protect human health and the environment. Potential exposures to contaminated soils and sediments at the Site would be significantly reduced by a combination of removal, containment, and institutional actions, as previously discussed under Alternatives 2 and 3. The disposal of dredged sediments at an upland location would require significant dewatering and related solids handling work, which could create potential short-term risks. However, the disposal of dredged sediments behind a steel/rock dam and bulkhead would require relatively little maintenance, and would provide an effective long-term containment method.

State Agency and Community Acceptance
Documentation of State agency and community acceptance of this alternative will be provided after the appropriate review process has been completed.

### 4.2.6 ALTERNATIVE 5

#### 4.2.6.1 Description

As with the preceding alternatives, this alternative includes engineering containment options to remediate hazardous wastes at the Site. However, under Alternative 5, the most highly affected upland soils and most of the dredged sediments would be removed to an approved off-site treatment or disposal facility. Therefore, this alternative would achieve the lowest residual chemical concentrations at the Site, and would require the least amount of fill in the Lauritzen Canal.

A. Off-Site Treatment and Disposal of Upland Soils

With this remedial component, upland soils with indicator chemical concentrations greater than 1,000 ppm would be excavated and transported to an off-site treatment and disposal facility. Unless EPA were to grant a treatability variance, these soils would need to be incinerated at an RCRA-permitted facility.

The approximate locations of these areas are shown in Figure 4-1. Based on the RI sampling results and field observations, approximately 2,000 cubic yards of soil with pesticide concentrations greater than 1,000 ppm would be removed from the Site. Most of these soils are located near the former United Heckathorn facility. The upland soils would be excavated to a depth of approximately 10 feet.

Conventional earth-moving equipment (e.g., backhoes and front-end loaders) would be used to excavate soils. Water would be used to wet down the upland excavation area, as necessary, to control dust emissions. Little or no dust generation is expected, since these soils are typically saturated due to the high water table in this area.

Once excavated, the upland soils would be loaded into trucks for removal from the Site, or temporarily stored near the excavation area until laboratory analysis results confirm that cleanup goals have been achieved. If temporary on-site storage is required, the soils would be placed on plastic sheeting, covered with a plastic tarp, and posted with hazardous waste warning signs. Truck trailers would need to be lined with plastic sheeting prior to loading excavated soils and sediments. After loading, the trailers would be covered over with tarpaulins. Before leaving the Site, the trucks would be appropriately decontaminated to remove dust. All waste soils and sediments will be manifested and transported by a registered waste hauler to an approved hazardous waste facility for treatment and/or disposal.

After laboratory test results confirm that upland soils have been adequately removed, the excavation areas will be backfilled with clean fill, compacted, and regraded as necessary to restore the original upland grade at the Site.

The affected embankment shoreline would be stabilized with a steel sheet pile bulkhead as previously described for Alternatives 2, 3 and 4. Various institutional controls (i.e., environmental monitoring and site-use restrictions) would be implemented to confirm the effectiveness of the cleanup actions and to reduce the potential for contact with residual contamination at the Site. These proposed institutional controls would be similar to those previously described for Alternative 2.

<u>Remediation of Lauritzen Canal Offshore Sediments</u>

Approximately 50,000 cubic yards (in situ volume) of offshore sediments containing greater than 0.2 ppm of total chlorinated pesticides would be dredged from the Lauritzen Canal, as shown in Figure 4-9. Assuming a bulking factor of 15 percent, approximately 57,000 cubic yards would need to be dredged.

Over half of these dredged sediments would be dewatered on site and transported to a permitted disposal facility, as described below. However, approximately 21,000 cubic yards would be contained behind the sheet pile bulkhead along the shoreline, as with Alternatives 2, 3, and 4.

Under Alternative 5, approximately 36,000 cubic yards of sediment would be dredged and removed from the Lauritzen Canal. Given the limited space available on site for dewatering these sediments, a closed clamshell bucket could be used to obtain sediments with a relatively low water content. These sediments would be transported to a central staging area, and unloaded to one or more drying beds. These areas would be diked off, and the sediments would be spread out to a depth of approximately 2 feet thick. The bed(s) would be tilled every one to two weeks, depending on local weather conditions, to promote even drying. Dust suppressants might be required to control fugitive dust emissions. However, use of these agents could also increase drying times.

Based on the available site areas, it is assumed that approximately 9,000 cubic yards of sediment could be dewatered per year. It would not be feasible to perform dredging and dewatering during the rainy season. Therefore, it would take approximately four years to complete the dredging and sediment dewatering phases of site remediation.

Given the presence of a railroad spur and train scale at the Site, and the large volume of sediments requiring off-site disposal, it may be cost effective to haul the dredged sediments by rail to an off-site disposal facility which accepts rail shipments. The closest hazardous waste disposal facility which could receive waste by rail is the U.S. Pollution Control, Inc., land disposal facility, in Utah.

4.2.6.2 Alternative 5 Assessment

Short-Term Effectiveness
The short-term risks associated with this alternative would be significantly greater than those previously described for Alternatives 2, 3, and 4, since Alternative 5 would require the greatest amount of excavation, dredging, and subsequent handling of soils and sediments at the Site.

The excavation and handling of upland soils would increase the potential for short-term human exposures and hence adverse effects due to ingestion, dermal contact, and inhalation of fugitive dust with adsorbed chemicals. However, the use of dust suppressants, and adherence to other site health and safety plan details, would significantly reduce these potential exposures.

Registered waste haulers would be used to transport the soils to an approved treatment/disposal facility. Although off-site transportation activities would create the potential for the environmental release of affected materials, the site health and safety plan would include provisions to reduce transportation risks. For example, standard procedures would include the verification of load limits, trailer hitch connections, lift-gate locks, and designation of an acceptable transportation route. Additionally, trailers would be lined and covered to reduce the potential for the release of contaminated soils and sediments while on the way.

As discussed above, the dredged sediments would need to be adequately dewatered before they are hauled away from the Site. This conditioning process would require that the sediments be spread out and tilled to promote drying. Dust control measures may be required to prevent wind erosion of affected sediments. There would be a potential risk of exposure by the heavy equipment operators involved in this conditioning operation.

Given the large quantity of contaminated sediments and soil which would need to be transported from the Site, this alternative would also present the greatest potential for accidental release during transportation to the off-site disposal facility. Since this alternative is estimated to require approximately four years to implement, the short-term risks would occur over a relatively long time period, compared to Alternatives 2 and 3.

<u>Long-Term Effectiveness and Permanence</u>
As with the previous alternatives, the affected soils and sediments would be remediated by a combination of response actions which have been proven to be effective. Contamination levels would be permanently lowered at the Site, with residual chemicals controlled by engineered containment structures. Upland soils with the highest contamination levels would be removed to an approved off-site treatment and disposal facility, permanently lowering residual contamination levels at the Site. The off-site incineration of these wastes would permanently reduce its volume and toxicity. Consistent with the reduction in pesticide-affected soils and sediments, Alternative 5 would result in the lowest long-term residual risks at the Site.

The long-term effectiveness and permanence of the implemented cleanup activities would be confirmed through environmental monitoring, including analyses of ground water, surface water, offshore sediments and estuarine organisms.

Reduction of Toxicity, Mobility, or Volume Through Treatment
The volume of wastes at the Site would be reduced to a greater degree than under Alternatives 2, 3, and 4. Upland soils and embankment sediments with total chlorinated pesticide concentrations greater than 1,000 ppm would be disposed of at an approved treatment and/or disposal facility.

Most of the dredged Lauritzen Canal offshore sediments would be dewatered on site and disposed at an approved off-site disposal facility. These sediments may not require off-site treatment prior to land disposal, given their relatively low pesticide concentrations.

Implementability
The proposed on-site containment activities for Alternative 5 could be implemented using standard equipment, materials, and construction methods, as previously described for Alternatives 2, 3, and 4. Conventional methods would be used to dredge and condition offshore sediments.

The dredge and fill activities proposed for Alternative 5 would need to be coordinated with and/or approved by various State and federal agencies, including EPA, the U.S. Army Corps of Engineers, and BCDC.

The incineration of upland soils could require significant delays. As previously discussed, EPA has determined that there is currently a national capacity limitation for the incineration of contaminated soil and debris. Thus, it may be difficult to schedule the treatment of hazardous waste from the Site using this technology.

Cost
Alternative 5 would be much more expensive than the preceding alternatives, with an estimated present worth cost of $ 25.5 million. A detailed breakdown of the capital and O&M costs for this alternative is presented in Table 4-5. The capital costs include soil and sediment excavation; off-site treatment and disposal; dredging, dewatering, and transportation of sediments; and construction of the proposed sheet pile bulkhead. These costs assume that dredge return water would not require significant treatment.

Operation and maintenance costs include periodic inspections and environmental monitoring.

Table 4-5 includes cost estimates for several other activities related to site remediation, including the removal and reconstruction of the pile-supported rail lines, wharf, and rail cranes. The estimated costs which LRTC would incur due to business interruptions during the remedial construction phase have not been included in Table 4-5. It should be noted that significant additional costs may be incurred if mitigation (i.e., creation of wetland habitat) is required for the on-site containment of dredged sediments.

<u>Compliance with ARARs</u>
The proposed remedial actions under Alternative 5 would be expected to comply with the ARARs identified and discussed in Section 2.2.

<u>Overall Protection of Human Health and the Environment</u>
Alternative 5 would be expected to protect human health and the environment. Potential exposures to contaminated soils and sediments at the Site would be significantly reduced by a combination of removal, containment, and institutional actions, as previously discussed under Alternatives 2, 3, and 4. However, since additional soils would be excavated, and more sediments would be dredged, this alternative would have the highest short-term risks. This alternative would have the highest short-term exposure risks due to the excavation, handling, and transportation of large volumes of soils and sediments. The potential health risks associated with construction activities would include ingestion of affected soil, dermal contact, and inhalation of dust released from affected soil. However, the potential for exposure would be significantly reduced or eliminated by adherence to appropriate health and safety protocols during the construction phase of remediation.

<u>State Agency and Community Acceptance</u>
Documentation of State agency and community acceptance of this alternative will be provided after the appropriate review process has been completed.

### 4.3 Comparative Analysis of Remedial Alternatives

In the following analysis, the relative advantages and disadvantages of each alternative are discussed to aid decision makers in selecting a preferred alternative. This comparative analysis uses the same criteria which were previously used to evaluate individual alternatives. These criteria include short-term effectiveness; long-term effectiveness and permanence; reduction of toxicity, mobility and volume; implementability; cost; compliance with ARARs; and overall protection of human health and the environment. The remaining two criteria (State agency and community acceptance) will be evaluated after review of comments on the RI and FS Reports. Table 4-6 summarizes the principal remedial components of each alternative. Table 4-7 summarizes the results of this comparative analysis for each of the alternatives.

4.3.1 SHORT-TERM EFFECTIVENESS

Alternative 3 is anticipated to have the greatest short-term effectiveness. This alternative involves the least amount of dredging, and the most chemical-affected offshore sediments would not need to be disturbed. Instead, most of these sediments would be contained in situ behind a rock/sheet pile dam and steel sheet pile bulkhead.

The short-term risks associated with Alternative 2 would be slightly greater, since a larger volume of sediment would be dredged. However, use of a hydraulic dredge and appropriate dredging procedures should control turbidity, reducing short-term risks.

Alternatives 4 and 5 would have the highest short-term risks. These alternatives involve the greatest amount of dredging, and require the most extensive handling of dredged sediments and upland soils. Workers potentially could be exposed to chlorinated pesticides while performing excavation, dewatering, and grading activities. If fugitive dust is not adequately controlled, there is also a potential risk to the off-site community located downwind of the Site. In addition to these factors, Alternative 5 would require the off-site transportation of the greatest amount of contaminated soils and sediments. Therefore, Alternative 5 has the highest short-term risks attributable to loading, unloading, and transportation of chemical-affected materials.

4.3.2 LONG-TERM EFFECTIVENESS AND PERMANENCE

Alternative 3 would afford the highest degree of long-term effectiveness and permanence for the containment of offshore sediments. Construction of a combination rock/sheet pile dam would create a permanent containment structure which would require minimal maintenance.

Other remedial components, including a steel sheet pile bulkhead, and asphalt concrete cap, would be similar for all of the alternatives (except Alternative 1, the "no action" alternative). With proper maintenance, these containment options would also provide long-term effectiveness and permanence.

### 4.3.3 REDUCTION OF TOXICITY, MOBILITY, AND VOLUME THROUGH TREATMENT

Alternatives 2 through 4 rely upon engineering containment to reduce the mobility of hazardous wastes at the Site. Alternative 5 uses treatment, as well as containment, to reduce the toxicity, mobility, and volume of contaminated soil at the Site. Under Alternative 5, soils with total chlorinated pesticide concentrations greater than 1,000 ppm would be incinerated at a permitted off-site facility.

### 4.3.4 IMPLEMENTABILITY

As previously noted, it may be difficult to incinerate the chemical-affected soils and sediments from the Site. The engineering containment options included in Alternatives 2 through 5 could be implemented using commercially available materials, equipment, and construction methods. The principal differences in implementability of the alternatives pertain to the containment method for offshore sediments. Alternative 2 is believed to be the most readily implementable alternative. Under this alternative, all of the dredged sediments would be placed behind a proposed sheet pile bulkhead, resulting in the filling of approximately 1.8 acres of the Lauritzen Canal. This containment structure would be located in an area with limited habitat value, due to the presence of a large wharf and numerous abandoned pilings. Based on preliminary discussions with BCDC, the placement of dredged sediments in this area may be more readily approved than other containment options which involve placing fill in the Bay.

Alternative 3 would require filling a larger area (approximately 2.6 acres), including approximately 1.9 acres of open water near the head of the Lauritzen Canal. Containment of sediment at this location would require the cooperation of adjacent property owners, since the proposed dam would eliminate existing waterfront on the western side of the Lauritzen Canal.

Alternatives 4 and 5 would require less fill in the canal than Alternatives 2 and 3, but may be more difficult to implement because of the limited upland area which is available for conditioning dredged sediments. While Alternative 5 would minimize the amount of fill in the Lauritzen Canal (approximately 1.4 acres), this alternative would require the most dredging (approximately 57,000 cubic yards). Most of these dredged sediments would be hauled to an off-site disposal facility.

Alternative 5 includes the off-site incineration of chemical-affected soils. This remedial component may be difficult to implement given the limited national incineration capacity which is currently available.

### 4.3.5 COST

Cost

The five alternatives developed for the Site range in cost from approximately $ 1,250,000 (Alternative 1) up to $ 25,504,000 (Alternative 5). These costs represent present worth values calculated over a 30-year time period at an interest rate of 5 percent, and do not include possible mitigation costs for filling part of the Lauritzen Canal (i.e., creation of new wetlands or additional waterfront access).

The costs for Alternative 1 ("No Action") include the installation of monitoring wells and air monitoring stations, routine environmental monitoring, and preparation of semiannual reports. Similar monitoring costs would be incurred for Alternatives 2 through 5.

Not counting Alternative 1, Alternative 3 has the least expensive capital costs. Under Alternative 3, the estimated costs to contain chemical-affected soils and sediments using capping, a rock/steel dam, and steel sheet pile bulkhead would be approximately $ 8,160,000. The on-site containment costs for Alternatives 2, 4, and 5 would be up to several million dollars higher than for Alternative 3.

Alternative 5 has the highest capital cost of approximately $ 24,720,000. This alternative's cost is significantly increased by the off-site incineration of upland soils and the off-site land disposal of offshore sediments. These two remedial components represent over half of the total direct capital costs for Alternative 5.

### 4.3.6 COMPLIANCE WITH ARARS

All of the alternatives which have been developed would be expected to comply with ARARS identified for the Site.

### 4.3.7 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

With the exception of Alternative 1 (no action), all of the proposed alternatives would satisfy the remedial goals and would be protective of human health and the environment. Alternative 1 does not include any remedial components. Instead, institutional measures would be implemented to reduce potential human health risks. The "no action" alternative would not be protective of the environment, since estuarine species would continue to be exposed to pesticide-affected sediments.

## 5.0 REFERENCES


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TABLE 1-1
CHEMICALS FORMERLY STORED AT THE UNITED HECKATHORN SITE

| | |
|---|---|
| Volatile Organic Compounds | |
| Alcohols | Methyl-iso-butyl-ketone (hexone) |
| Kerosene | Paintbase spirits |
| Ketones | Solvents |
| Methylene chloride | Xylenes |
| Base-Neutral Compounds | |
| Aqua ammonia | |
| Cresylic acid (Cresol) | |
| Dinitro-o-sec-butylphenol (Dinoseb) | |
| Chlorinated Pesticides | |
| DDT | Aldrin |
| Telone | Endrin |
| Vidden | BHC |
| Ovotran (Ovex) | Heptachlor |
| Dieldrin | |
| Chlorophenoxy Herbicides | |
| 2,4-D (Esteron) | |
| MCP amine weed killer (MCPA) | |
| 2,4,5-T (Weedone) | |
| Organophosphorus Pesticides | |
| Malathion | Parathion |
| TEPP-40 | Ethyl Parathion |
| Guthion | Bidrin (Dicrotophos) |
| Corrosives | |
| Caustic soda | Trisodium phosphate |
| Aqua ammonia | Muriatic acid (HCl) |
| Other Chemicals | |
| Dormant flowable oils | Fertilizers |
| Heavy solvents | Monsanto "Steerol" |
| Darvel 200 | Napco Agrimul 10-A |
| | Silicones |

Sources: Regional Water Quality Control Board, #2 Checking Program Report for United Heckathorn, Inc., June 15, 1960, and the depositions of former employees at the United Heckathorn facility.

TABLE 2-1

HAZARDOUS WASTE CLASSIFICATION CONCENTRATIONS

| Indicator Chemicals | DOHS (1) STLC mg/l | DOHS (1) TTLC mg/kg | DOHS (1) TTLC extremely hazardous mg/kg | EPA EP (2) Toxicity mg/l | EPA TCLP (3) mg/l |
|---|---|---|---|---|---|
| Aldrin | 0.14 | 1.4 | 140 | --- | --- |
| DDD | 0.10 * | 1.0 * | --- | --- | --- |
| DDE | 0.10 * | 1.0 * | --- | --- | --- |
| DDT | 0.10 * | 1.0 * | --- | --- | --- |
| Dieldrin | 0.8 | 8.0 | 800 | --- | --- |
| Endrin | 0.02 | 0.2 | 20 | 0.02 | 0.02 |
| Chlordane | 0.25 | 2.5 | 250 | --- | 0.03 |
| BHC (Lindane) | 0.40 | 4.0 | 400 | 0.4 | 0.4 |

Notes:

* - Value for DDD, DDE and DDT is for the compounds individually or in combination.

(1) Source: CCR Title 22, Sections 66699 and 66723.

(2) Source: 40 CFR 261.24 effective until September 25, 1990 for large quantity generators.

(3) Source: 40 CFR 261.24 effective on September 25, 1990 for large quantity generators.

TABLE 2-2

SURFACE-WATER CRITERIA

| | National Ambient Water-Quality Criteria<br>Protection of Salt-Water Aquatic Life | |
|---|---|---|
| Indicator Chemicals | 24-Hour Average ng/l | Maximum ng/l |
| Aldrin | --- | 1.3 ug/l |
| DDD | --- | --- |
| DDE | --- | --- |
| DDT | 1 | 130 |
| Dieldrin | 1.9 | 710 |
| Endrin | 2.3 | 37 |
| Chlordane | 4 | 90 |
| BHC | --- | 160 (1) |

Note: (1) Concentration for lindane.

Source: Quality Criteria for Water, EPA, May 1, 1986.

TABLE 2-3

RESOURCE CONSERVATION RECOVERY ACT (RCRA)
LAND DISPOSAL RESTRICTIONS

TREATMENT STANDARDS

| Indicator Chemicals | Constituent Concentrations (1) in Waste (CCW) mg/kg |
|---|---|
| Aldrin | 0.066 |
| o,p'-DDD | 0.087 |
| p,p'-DDD | 0.087 |
| o,p'-DDE | 0.087 |
| p,p'-DDE | 0.087 |
| o,p'-DDT | 0.087 |
| p,p'-DDT | 0.087 |
| Dieldrin | 0.13 |
| Endrin | 0.13 |
| Chlordane | 0.13 |
| BHC (Lindane) | 0.066 |

Note: (1) concentration in non-wastewaters; not in extract of waste.

Source: 40 CFR 268.43

TABLE 2-4

PROPOSED CLEANUP GOALS

| Site Area | Remedial Goal |
|---|---|
| Upland Soils | Remediation of soils containing indicator chemical concentrations greater than 1 ppm. |
| Embankment Sediments | Remediation of embankment sediments containing indicator chemical concentrations greater than 1 ppm. |
| Lauritzen Canal Offshore Sediments | Remediation of sediments containing total DDT concentrations greater than 0.2 ppm. |

Table 3-1: GENERAL RESPONSE ACTIONS AND REMEDIAL TECHNOLOGIES FOR UPLAND AREA SOILS

| GENERAL RESPONSE ACTION | REMEDIAL TECHNOLOGY | DESCRIPTION | Screening Comments |
|---|---|---|---|
| No Action | No Action | Cease all site cleanup activities | required by CERCLA |
| Institutional Actions: | Land use restrictions | Apply legal restrictions to limit future use. | potentially applicable |
| | Site Access Restrictions | Maintain fencing, warning signs, and other security measures to prevent unauthorized site access. | potentially applicable |
| | Enviornmental Monitoring | Collect and analyze samples from air and ground water to evaluate potential contaminant migration from upland area of site. | potentially applicable |
| Removal | Soil excavation | Use conventional earth-moving equipment to excavate soils that are chemical-affected. | potentially applicable |
| Containment | Horizontal barriers | Modify drainage; seal surface | potentially applicable |
| Treatment: | Physical treatment | Use physical processes to immobilize chemicals within or remove them from soil. | potentially applicable |
| | Biological treatment | Use microbial biodegradation to reduce toxicity and volume of chemical-affected soils. | eliminated |
| | Chemical treatment | Chemically transform compounds of concern into less toxic substances. | potentially applicable |
| | Thermal treatment | Incinerate compounds of concern | potentially applicable |
| Disposal | Off-site disposal | Transfer chemical-affected soils to an approved off-site land disposal facility. | potentially applicable |

Table 3-2: GENERAL RESPONSE ACTIONS AND REMEDIAL TECHNOLOGIES FOR EMBANKMENT SEDIMENTS

| GENERAL RESPONSE ACTION | REMEDIAL TECHNOLOGY | DESCRIPTION | Screening Comments |
|---|---|---|---|
| No Action | No Action | Cease all site cleanup activities | required by CERCLA |
| Institutional Actions | Land use restrictions | Apply deed restrictions to limit future land use. | potentially applicable |
| | Site access restrictions | Maintain fencing, warning signs, and other security measures to prevent unauthorized site access. | potentially applicable |
| | Environmental monitoring | Collect and analyze samples to evaluate potential contaminant migration from site. Perform visual inspections for signs of embankment erosion. | potentially applicable |
| Removal | Sediment excavation | Use conventional earth-moving equipment to excavate chemical-affected sediments. | potentially applicable |
| Containment | Shoreline stabilization | Reduce erosion potential through the install-ation of a revetment, seawall, or bulkhead. | potentially applicable |
| Treatment | Physical treatment | Use physical processes to immobilize chemicals within or remove them from embankment sediments. | potentially applicable |
| | Biological treatment | Use microbial biodegradation to reduce toxicity and volume of chemical-affected sediments. | eliminated |
| | Chemical treatment | Chemically transform compounds of concern into less toxic substances. | potentially applicable |
| | Thermal treatment | Incinerate compounds to reduce their toxicity and volume. | potentially applicable |
| Disposal | Off-site disposal | Transer chemical-affected sediments to an approved off-site land disposal facility. | potentially applicable |

Table 3-3: GENERAL RESPONSE ACTIONS AND REMEDIAL TECHNOLOGIES FOR LAURITZEN CANAL SEDIMENTS

| GENERAL RESPONSE ACTION | REMEDIAL TECHNOLOGY | DESCRIPTION | SCREENING COMMENTS |
|---|---|---|---|
| No Action | No action | Cease all cleanup activities | required by CERCLA |
| Institutional Actions: | Water-use restrictions | Maintain existing warning signs against fishing in Lauritzen Canal waters. | potentially applicable |
| | Environmental monitoring | Collect sediment, water, or biological samples to periodically assess conditions in Lauritzen Canal. | potentially applicable |
| Removal | Sediment dredging | Use dredging equipment to remove chemical-affected benthic sediments from Lauritzen Canal. | potentially applicable |
| Containment | Containment in Lauritzen Canal or upland area of Site | Reduce mobility of chemical-affected sediments by containing in the Lauritzen Canal or in an upland area of site. | potentially applicable |
| Disposal | Off-site disposal | Transer chemical-affected sediments to an approved off-site disposal facility. | potentially applicable |
| Treatment: | Physical treatment | Use physical processes to immobilize chemicals within or remove them from offshore sediments. | potentially applicable |
| | Biological treatment | Use microbial biodegradation to reduce toxicity and volume of chemical-affected offshore sediments. | eliminated |
| | Chemical treatment | Chemically transform compounds of concern into less toxic substances. | potentially applicable |
| | Thermal treatment | Incinerate compounds to reduce their toxicity and volume. | potentially applicable |

TABLE 3-4: PROCESS OPTION DESCRIPTIONS FOR UPLAND AREA SOILS

| REMEDIAL TECHNOLOGY | PROCESS OPTION | DESCRIPTION |
|---|---|---|
| No Action | No Action | Cease all site cleanup activities. |
| Land Use Restrictions | Deed restrictions | File a deed restriction to limit future land use. |
| Site Access Restrictions | Access control measures | Maintain existing fencing, security system, and warning signs around site. |
| Environmental Monitoring | Visual inspections and chemical analyses | Inspect upland area for evidence of contaminant migration and/or integrity of remedial measures; chemical analyses of ground-water and/or air samples from the site. |
| Soil Excavation | Excavate soils | Excavate soils with conventional earthworking equipment (e.g., backhoes, front-end loaders, cranes). |
| Horizontal Barriers | Modify drainage, grade, or seal surface | Grade and cap upland area soils to reduce percolation of runoff into contaminated soils. Cap with asphalt, concrete, and/or clay. |
| Physical Treatment | Soil extraction | Selectively remove chemicals of concern from soils by washing with detergent or solvent solution. |
| | Fixation | Combine affected soils with cement or other fixation agent to create a physically stable matrix. |
| Chemical Treatment | Dechlorination | Strip chlorine from indicator chemicals by treating soils with alkali metal and polyethylene glycol. |
| Thermal Treatmement | Incineration | Combust soils with rotary kiln, multiple hearth furnace, or other incineration device to degrade chemicals of concern. |
| | Vitrification | Use electricity to heat up soils, transforming them into a stable glass-like material. |
| Off-Site Disposal | Off-site land disposal | Dispose of affected soils in permitted landfill. |

TABLE 3-5: PROCESS OPTION DESCRIPTIONS FOR EMBANKMENT SEDIMENTS

| REMEDIAL TECHNOLOGY | PROCESS OPTION | DESCRIPTION |
|---|---|---|
| No Action | No Action | Cease all site cleanup activities |
| Land Use Restrictions | Deed restrictions | File a deed restriction to limit future land use. |
| Site Access Restrictions | Access control measures | Maintain existing fencing, security system, and warning signs around site. |
| Environmental Monitoring | Visual inspection | Periodically inspect embankment sediments for signs of erosion (e.g., rills, piping, slumping, etc.) |
| Soil Excavation | Excavate sediments | Excavate sediments with conventional earthworking equipment (e.g., backhoes, front-end loaders, cranes) |
| Shoreline Stabilization | Revetments, seawalls, and bulkheads | Minimize erosion of embankment sediments by constructing a barrier (e.g., riprap, sheet pile, or other containment structure) along shoreline. |
| Physical Treatment | Soil extraction | Selectively remove chemicals of concern from sediments by washing with detergent or solvent solution. |
| | Fixation | Combine affected sediments with cement or other fixation agent to create a physically stable matrix. |
| Chemical Treatment | Dechlorination | Strip chlorine from indicator chemicals by chemically reacting sediments with alkali metal and polyethylene glycol. |
| Thermal Treatment | Incineration | Combust soils with rotary kiln, multiple hearth furnace, or other incineration device to degrade chemicals of concern. |
| | Vitrification | Use electricity to heat up sediments transforming them into a stable glass-like material. |
| Off-Site Disposal | Off-site land disposal | Dispose of affected sediments in permitted landfill. |

TABLE 3-6: PROCESS OPTION DESCRIPTIONS FOR LAURITZEN CANAL SEDIMENTS

| REMEDIAL TECHNOLOGY | PROCESS OPTION | DESCRIPTION |
|---|---|---|
| No Action | No Action | Cease all site cleanup activities. |
| Water-Use Restrictions | Water-use restrictions | Continue to post warning signs against fishing in Lauritzen Canal waters. |
| Environmental Monitoring | Visual observations and chemical analyses of off-shore sediments, biota, and surface water | Periodically sample and chemically analyze water, sediment, and marine organisms (e.g., fish, mussels, benthic infauna) to evaluate condition of Lauritzen Canal environment. Visually inspect remedial measures used to contain sediments. |
| Sediment Dredging | Hydraulic dredging<br>Clamshell dredging | Use conventional dredging equipment to remove chemical-affected benthic sediments from Lauritzen Canal. |
| Containment in Lauritzen Canal | Encapsulation with multi-media cap | Cover over affected sediments in place with filter materials. |
| | Containment behind rock dam or sheet pile bulkhead | Construct a dam or bulkhead to contain dredged sediments. Install clay/asphalt cap over dredged sediments. |
| Containment in Upland Area of Site | Containment in diked area or excavated pond | Dispose of dredged sediments in engineered containment area at upland part of site. |
| Off-Site Disposal | Disposal at ocean dumping site, or other in-bay or upland location | Dispose of affected sediments in permitted ocean dumping site, along Parr Canal, within graving dock, or at other approved disposal site. |
| Physical Treatment | Sediment extraction | Selectively remove chemicals of concern from sediments by washing with detergent or solvent solution. |
| | Fixation | Combine affected sediments with cement or other fixation agent to create a physically stable matrix. |
| Chemical Treatment | Dechlorination | Strip chlorine from indicator chemicals by chemically reacting sediments with alkali metal and polyethylene glycol. |

TABLE 3-6: PROCESS OPTION DESCRIPTIONS FOR LAURITZEN CANAL SEDIMENTS

| REMEDIAL TECHNOLOGY | PROCESS OPTION | DESCRIPTION |
|---|---|---|
| Thermal Destruction | Incineration | Combust sediments with rotary kiln, multiple hearth furnace, or other incineration device to degrade chemicals of concern. |
| | Vitrification | Use electricity to heat up sediments transforming them into a stable glass-like material. |

TABLE 3-7: PROCESS OPTION SCREENING FOR UPLAND AREA SOILS

| REMEDIAL TECHNOLOGY | PROCESS OPTION | EFFECTIVENESS | IMPLEMENTABILITY | COST | SCREENING DECISION |
|---|---|---|---|---|---|
| No Action | No Action | - | + | + | retained |
| Land Use Restrictions | Deed restrictions | + | + | 0 | retained |
| | Access control measures | + | + | + | retained |
| Monitoring | Visual inspections | + | + | 0 | retained |
| | Chemical analyses | + | + | 0 | retained |
| Soil Excavation | Excavate soils | + | + | 0 | retained |
| Horizontal Barriers | Modify drainage | + | + | + | retained |
| | Grade surface | + | + | + | retained |
| | Seal surface with cap | + | + | + | retained |
| Physical Treatment | Soil extraction | - | - | - | screened out |
| | Fixation | 0 | 0 | - | screened out |
| Chemical Treatment | Dechlorination | - | - | - | screened out |
| Thermal Treatment | Incineration | + | 0 | - | retained |
| | Vitrification | 0 | - | - | screened out |
| Off-Site Disposal | Off-site land disposal | + | + | 0 | retained |

NOTE: + = highly effective, readily implementable, or low cost
0 = moderately effective, implementable, or moderate cost
- = little to no effectiveness, difficult to implement, or high cost

TABLE 3-8: PROCESS OPTION SCREENING FOR EMBANKMENT SEDIMENTS

| REMEDIAL TECHNOLOGY | PROCESS OPTION | EFFECTIVENESS | IMPLEMENTABILITY | COST | SCREENING DECISION |
|---|---|---|---|---|---|
| No Action | No Action | - | + | + | retained |
| Site Access Restrictions | Deed restrictions | + | + | 0 | retained |
| | Access control measures | + | + | + | retained |
| Environmental Monitoring | Visual Inspection | + | + | + | retained |
| Sediment Excavation | Excavate sediments | + | 0 | 0 | retained |
| Shoreline Stabilization | Revetment | 0 | - | 0 | screened out |
| | Seawall | + | 0 | - | screened out |
| | Bulkhead | + | + | 0 | retained |
| Physical Treatment | Soil extraction | - | - | - | screened out |
| | Fixation | 0 | 0 | - | screened out |
| Chemical Treatment | Dechlorination | - | - | - | screened out |
| Thermal Destruction | Incineration | + | 0 | - | retained |
| | Vitrification | + | - | | screened out |
| Off-Site Disposal | Off-site land disposal | + | + | 0 | retained |

NOTE: + = highly effective, readily implementable, or low cost
0 = moderately effective, implementable, or moderate cost
- = little to no effectiveness, difficult to implement, or high cost

TABLE 3-9: PROCESS OPTION SCREENING FOR LAURITZEN CANAL SEDIMENTS

| REMEDIAL TECHNOLOGY | PROCESS OPTION | EFFECTIVENESS | IMPLEMENTABILITY | COST | SCREENING DEICISION |
|---|---|---|---|---|---|
| No Action | No action | - | + | + | retained |
| Water Use Restrictions | Water use restrictions | 0 | 0 | + | retained |
| Environmental Monitoring | Visual observations | + | + | + | retained |
| | Chemical analyses | + | + | 0 | retained |
| Sediment Dredging | Hydraulic dredging | + | + | 0 | retained |
| | Clamshell dredging | + | + | 0 | retained |
| Containment in Lauritzen Canal | Encapsulation with multi-media cap | 0 | + | 0 | screened out |
| | Containment behind rock dam and/or sheetpile bulkhead | + | 0 | 0 | retained |
| Containment in Upland Area of site | Containment in diked area or excavated pond | 0 | 0 | 0 | retained |
| Physical Treatment | Sediment extraction | - | 0 | - | screened out |
| | Fixation | 0 | 0 | - | retained |
| Chemical Treatment | Dechlorination | - | - | - | screened out |
| Thermal Treatment | Incineration | + | 0 | - | screened out |
| | Vitrification | 0 | - | - | screened out |
| Off-Site Disposal | Ocean disposal | 0 | - | + | screened out |
| | Graving dock | + | - | 0 | screened out |
| | Parr Canal property | + | - | 0 | screened out |
| | Permitted landfill | 0 | 0 | - | retained |

NOTE: + = highly effective, readily implementable, or low cost
0 = moderately effective, implementable, or moderate cost
- = little to no effectiveness, difficult to implement, or high cost

TABLE 3-10: SUMMARY OF REPRESENTATIVE PROCESS OPTIONS

| GENERAL RESPONSE ACTION | PROCESS OPTION | ENVIRONMENTAL MEDIA: Upland Soils | ENVIRONMENTAL MEDIA: Embankment Sediments | ENVIRONMENTAL MEDIA: Lauritzen Canal Sediments |
|---|---|---|---|---|
| No Action | No Action | X | X | X |
| Institutional Actions: | Deed restrictions | X | X | |
| | Access control measures | X | X | |
| | Water use restrictions | | | X |
| | Visual inspections | X | X | X |
| | Chemical analyses | X | | X |
| Removal: | Excavate soils/sediments | X | X | |
| | Hydraulic dredging | | | X |
| | Clamshell dredging | | | X |
| Containment: | Modify drainage, grade and seal surface | X | | |
| | Shoreline stabilization with sheet-pile bulkhead | | X | |
| | Contain sediments behind rock dam and/or sheet-pile bulkhead | | | X |
| | Contain sediments in diked or excavated upland area of Site | | | X |
| Treatment | Fixation | | | X |
| | Incineration | X | X | |
| Disposal | Off-site land disposal | X | X | X |

TABLE 4-1: ESTIMATED COSTS FOR ALTERNATIVE 1

| | Quantity | Unit | LABOR UNIT COST | LABOR Labor Cost | MATERIALS Unit Cost | MATERIALS Materials Cost | TOTAL COST |
|---|---|---|---|---|---|---|---|
| CAPITAL COSTS - DIRECT | | | | | | | |
| Install monitoring wells | 8 | ea | 1500 | 12000 | 500 | 4000 | 16000 |
| Install air monitoring stations | 4 | ea | 2600 | 10400 | 4000 | 16000 | 26400 |
| | | | | | | Subtotal: | 42400 |
| ANNUAL MONITORING COSTS: | | | | | | | |
| Sediment sampling & analysis | 2 | ea | 2000 | 4000 | 4000 | 8000 | 12,000 |
| Biological sampling & analysis | 1 | ea | 16000 | 16000 | 7500 | 7500 | 23,500 |
| Ground-water sampling & analysi | 2 | ea | 2200 | 4400 | 2000 | 4000 | 8,400 |
| Air monitoring | 4 | ea | 4500 | 18000 | 2500 | 10000 | 28,000 |
| Monitoring reports | 2 | ea | 3000 | 6000 | 300 | 600 | 6,600 |
| | | | | | | Subtotal: | 78,500 |
| | | | | Present Worth (30 yr term, 5% interest rate): | | | 1,206,737 |
| | | | | TOTAL PRESENT WORTH (Capital plus O&M costs): | | | 1,249,137 |

TABLE 4-2: ESTIMATED COSTS FOR ALTERNATIVE 2

| | Quantity | Unit | LABOR UNIT COST | LABOR Labor Cost | MATERIALS Unit Cost | MATERIALS Materials Cost | TOTAL COST |
|---|---|---|---|---|---|---|---|
| CAPITAL COSTS - DIRECT | | | | | | | |
| GRADING, CAPPING, DRAINAGE CONTROLS: | | | | | | | |
| Mob/demob | 1 | ea | 5000 | 5000 | | | 5,000 |
| Site prep | 1 | ea | 6000 | 6000 | | | 6,000 |
| Grading & compacting | 12,375 | sy | 2 | 24750 | | 0 | 24,750 |
| Asphalt surface seal w/ AB | 24,750 | sy | | 0 | 12.00 | 297,000 | 297,000 |
| | | | | | | Subtotal: | 332,750 |
| CONSTRUCTION OF SHEET PILE BULKHEAD: | | | | | | | |
| Mob/Demob | 1 | ea | 5000 | 5000 | | | 5,000 |
| Arbed sheet pile sections | 1,200 | lf | 350 | 420000 | 2532 | 3,038,400 | 3,458,400 |
| Tie rods under dock | 1,200 | lf | 184 | 220500 | 551 | 661,500 | 882,000 |
| Tie rods north of dock | 1,200 | lf | 200 | 240000 | 100 | 120,000 | 360,000 |
| HP piles (12x63) | 1,200 | 12 lf | 154 | 185220 | 222 | 266,712 | 451,932 |
| HP piles (12x53) | 1,200 | 12 lf | 154 | 185220 | 374 | 448,764 | 633,984 |
| Concrete deadmen | 660 | cy | | 0 | 400 | 264,000 | 264,000 |
| Painting steel sheets | 60000 | sf | 1 | 45000 | 1 | 45,000 | 90,000 |
| Cathodic Protection | 1200 | lf | | | 50 | 60,000 | 60,000 |
| Wales | 1200 | lf | 13 | 15000 | 38 | 45,000 | 60,000 |
| Geotextile backing | 1200 | lf | 23 | 27000 | 23 | 27,000 | 54,000 |
| Reinforced concrete cap | 1200 | lf | 400 | 480000 | 400 | 480,000 | 960,000 |
| Remove and replace fenders | 1200 | lf | 200 | 240000 | | 0 | 240,000 |
| | | | | | | Subtotal: | 7,519,316 |
| DREDGING LAURITZEN CANAL SEDIMENTS: | | | | | | | |
| Mob/demob | 1 | ea | 100000 | | | | 100,000 |
| Hydraulic dredging | 48000 | cy | 10 | 480000 | | | 480,000 |
| Gravel/geotextile cap | 8700 | sy | 1 | 8700 | 5 | 43500 | 52,200 |
| Water quality monitoring | 1 | ea | 20000 | 20000 | 2000 | 2000 | 22,000 |
| Confirmation sampling plan | 1 | ea | 2000 | 2000 | 3000 | 3000 | 5,000 |
| | | | | | | Subtotal: | 659,200 |

TABLE 4-2: ESTIMATED COSTS FOR ALTERNATIVE 2

| | Quantity | Unit | LABOR UNIT COST | LABOR Labor Cost | MATERIALS Unit Cost | MATERIALS Materials Cost | TOTAL COST |
|---|---|---|---|---|---|---|---|
| **Miscellaneous direct costs:** | | | | | | | |
| Modify Rail Cranes | 1 | ea | 100000 | 100000 | 100000 | 100000 | 200000 |
| Install monitoring wells | 8 | ea | 1500 | 12000 | 500 | 4000 | 16000 |
| | | | | | | Subtotal: | 216000 |
| | | | | | | TOTAL DIRECT COSTS: | 8,727,266 |
| INDIRECT COSTS: | | | | | | | |
| Engineering design | 0.10 * total direct | | | | | | 872,727 |
| Construction management | 0.15 * total direct | | | | | | 1,309,090 |
| | | | | | | TOTAL INDIRECT COSTS: | 2,181,817 |
| | | | | | | TOTAL CAPITAL (DIRECT & INDIRECT) | 10,909,083 |
| **ANNUAL MONITORING COSTS:** | | | | | | | |
| Sediment sampling & analysis | 2 | ea | 2000 | 4000 | 4000 | 8000 | 12,000 |
| Biological sampling & analys | 1 | ea | 16000 | 16000 | 7500 | 7500 | 23,500 |
| Ground-water sampling & anal | 2 | ea | 2200 | 4400 | 2000 | 4000 | 8,400 |
| Inspect bulkhead and dam | 1 | ea | 20000 | 20000 | 1000 | 1000 | 21,000 |
| Monitoring reports | 2 | ea | 3000 | 6000 | 300 | 600 | 6,600 |
| | | | | | | Subtotal: | 71,500 |
| | | | | | | Present Worth (30 yr term, 5% interest rate): | 1,099,130 |
| | | | | | | TOTAL PRESENT WORTH (Capital plus O&M costs): | 12,008,213 |

TABLE 4-3: ESTIMATED COSTS FOR ALTERNATIVE 3

| | Quantity | Unit | LABOR UNIT COST | LABOR Labor Cost | MATERIALS Unit Cost | MATERIALS Materials Cost | | TOTAL COST |
|---|---|---|---|---|---|---|---|---|
| **CAPITAL COSTS - DIRECT** | | | | | | | | |
| **GRADING, CAPPING, DRAINAGE CONTROLS:** | | | | | | | | |
| Mob/demob | 1 | ea | | 5000 | | | | 5,000 |
| Site prep | 1 | ea | 6000 | 6000 | | | | 6,000 |
| Grading and compacting | 12,375 | sy | 2 | 24750 | | 0 | | 24,750 |
| Asphalt surface seal w/ AB | 24,750 | sy | | 0 | 12.00 | 297,000 | | 297,000 |
| | | | | | | | Subtotal: | 332,750 |
| **CONSTRUCTION OF SHEET PILE BULKHEAD:** | | | | | | | | |
| Mob/Demob | 1 | ea | 5000 | 5000 | | | | 5,000 |
| Arbed sheet pile sections | 750 | lf | 350 | 262500 | 2532 | 1,899,000 | | 2,161,500 |
| Tie rods | 750 | lf | 184 | 137813 | 551 | 413,438 | | 551,250 |
| HP piles (12x63) | 750 | 12 lf | 154 | 115763 | 222 | 166,695 | | 282,458 |
| HP piles (12x53) | 750 | 12 lf | 154 | 115763 | 374 | 280,478 | | 396,240 |
| Concrete deadmen | 412 | cy | | 0 | 400 | 164,800 | | 164,800 |
| Painting steel sheets | 37500 | sf | 1 | 28125 | 1 | 28,125 | | 56,250 |
| Cathodic Protection | 750 | lf | | | 50 | 37,500 | | 37,500 |
| Wales | 750 | lf | 13 | 9375 | 38 | 28,125 | | 37,500 |
| Geotextile backing | 750 | lf | 23 | 16875 | 23 | 16,875 | | 33,750 |
| Remove and replace fenders | 750 | lf | 200 | 150000 | | | | 150,000 |
| Reinforced concrete cap | 750 | lf | 400 | 300000 | 400 | 300,000 | | 600,000 |
| | | | | | | | Subtotal: | 4,476,248 |
| **CONSTRUCTION OF SHEET PILE/ROCK DAM:** | | | | | | | | |
| Subexcavation | 3377 | cy | 10 | 33768 | | 0 | | 33,768 |
| Gravel backfill | 4737 | ton | 5 | 23685 | 15 | 71054 | | 94,738 |
| Steel sheet piles | 8800 | sf | 5 | 44000 | 18 | 154000 | | 198,000 |
| Coal tar epoxy coating | 8800 | sf | 1 | 6600 | 1 | 6600 | | 13,200 |
| Cathodic protection | 8800 | sf | | 0 | 1 | 10032 | | 10,032 |
| Rock | 4791 | ton | 5 | 23953 | 25 | 119763 | | 143,715 |
| Geotextile | 34500 | sf | 0 | 3450 | 1 | 17250 | | 20,700 |
| Extend RCP storm drain | 500 | lf | 140 | 70000 | 530 | 265000 | | 335,000 |
| | | | | | | | Subtotal: | 849,153 |

TABLE 4-3: ESTIMATED COSTS FOR ALTERNATIVE 3

| | Quantity | Unit | LABOR UNIT COST | LABOR Labor Cost | MATERIALS Unit Cost | MATERIALS Materials Cost | TOTAL COST |
|---|---|---|---|---|---|---|---|
| DREDGING LAURITZEN CANAL SEDIMENTS: | | | | | | | |
| Mob/demob | 1 | ea | 100000 | | | | 100,000 |
| Hydraulic dredging | 38000 | cy | 10 | 380000 | | | 380,000 |
| Clay/asphalt cap | 9600 | sy | 6 | 57600 | 6 | 57600 | 115,200 |
| Gravel/geotextile cap | 5000 | sy | 1 | 5000 | 5 | 25000 | 30,000 |
| Water quality monitoring | 1 | ea | 20000 | 20000 | 2000 | 2000 | 22,000 |
| Confirmation sampling plan | 1 | ea | 2000 | 2000 | 3000 | 3000 | 5,000 |
| | | | | | | Subtotal: | 652,200 |
| OTHER DIRECT CAPITAL COSTS: | | | | | | | |
| Modify Rail Cranes | 1 | ea | 100000 | 100000 | 100000 | 100000 | 200000 |
| Install monitoring wells | 8 | ea | 1500 | 12000 | 500 | 4000 | 16000 |
| | | | | | | Subtotal: | 216000 |
| | | | | | | TOTAL DIRECT COSTS: | 6,526,351 |
| CAPITAL COSTS - INDIRECT: | | | | | | | |
| Engineering design | 0.10 * total direct | | | | | | 652,635 |
| Construction management | 0.15 * total direct | | | | | | 978,953 |
| | | | | | | TOTAL INDIRECT COSTS: | 1,631,588 |
| | | | | | | TOTAL CAPITAL (DIRECT & INDIRECT) | 8,157,938 |
| ANNUAL MONITORING COSTS: | | | | | | | |
| Sediment sampling & analyses | 2 | ea | 2000 | 4000 | 4000 | 8000 | 12,000 |
| Biological sampling & anal | 1 | ea | 16000 | 16000 | 7500 | 7500 | 23,500 |
| Ground-water sampling & anal | 2 | ea | 2200 | 4400 | 2000 | 4000 | 8,400 |
| Inspect bulkhead and dam | 1 | ea | 20000 | 20000 | 1000 | 1000 | 21,000 |
| Monitoring reports | 2 | ea | 3000 | 6000 | 300 | 600 | 6,600 |
| | | | | | | Subtotal: | 71,500 |
| | | | | | | Present Worth (30 year term, 5% interest rate): | 785,532 |
| | | | | | | TOTAL PRESENT WORTH (Capital plus O&M costs): | 8,943,470 |

TABLE 4-4: ESTIMATED COSTS FOR ALTERNATIVE 4

| | Quantity | Unit | LABOR UNIT COST | LABOR Labor Cost | MATERIALS Unit Cost | MATERIALS Materials Cost | | TOTAL COST |
|---|---|---|---|---|---|---|---|---|
| CAPITAL COSTS - DIRECT | | | | | | | | |
| GRADING, CAPPING, DRAINAGE CONTROLS: | | | | | | | | |
| Mob/demob | 1 | ea | | 5000 | | | | 5,000 |
| Site prep | 1 | ea | 6000 | 6000 | | | | 6,000 |
| Grading and compacting | 12,375 | sy | 2 | 24750 | | 0 | | 24,750 |
| Asphalt surface seal w/ AB | 24,750 | sy | | 0 | 12.00 | 297,000 | | 297,000 |
| | | | | | | | Subtotal: | 332,750 |
| CONSTRUCTION OF SHEET PILE BULKHEAD: | | | | | | | | |
| Mob/Demob | 1 | ea | 5000 | 5000 | | | | 5,000 |
| Arbed sheet pile sections | 1,055 | lf | 350 | 369250 | 2532 | 2,671,260 | | 3,040,510 |
| Tie rods | 1,055 | lf | 184 | 193856 | 551 | 581,569 | | 775,425 |
| HP piles (12x63) | 1,055 | 12 lf | 154 | 162839 | 222 | 234,484 | | 397,324 |
| HP piles (12x53) | 1,055 | 12 lf | 154 | 162839 | 374 | 394,538 | | 557,378 |
| Concrete deadmen | 580 | cy | | 0 | 400 | 232,000 | | 232,000 |
| Painting steel sheets | 52750 | sf | 1 | 39563 | 1 | 39,563 | | 79,125 |
| Cathodic Protection | 1055 | lf | | | 50 | 52,750 | | 52,750 |
| Wales | 1055 | lf | 13 | 13188 | 38 | 39,563 | | 52,750 |
| Geotextile backing | 1055 | lf | 23 | 23738 | 23 | 23,738 | | 47,475 |
| Remove and replace fenders | 1055 | lf | 200 | 211000 | | | | 211,000 |
| Reinforced concrete cap | 1055 | lf | 400 | 422000 | 400 | 422,000 | | 844,000 |
| | | | | | | | Subtotal: | 6,294,736 |

TABLE 4-4: ESTIMATED COSTS FOR ALTERNATIVE 4

| | Quantity | Unit | LABOR UNIT COST | LABOR Labor Cost | MATERIALS Unit Cost | MATERIALS Materials Cost | TOTAL COST |
|---|---|---|---|---|---|---|---|
| **CONSTRUCTION OF SHEET PILE/ROCK DAM:** | | | | | | | |
| Subexcavation | 4640 | cy | 10 | 46400 | | 0 | 46,400 |
| Gravel backfill | 6510 | ton | 5 | 32550 | 15 | 97650 | 130,200 |
| Steel sheet piles | 6730 | sf | 5 | 33650 | 18 | 117775 | 151,425 |
| Coal tar epoxy coating | 6730 | sf | 1 | 5048 | 1 | 5048 | 10,095 |
| Cathodic protection | 6730 | sf | | 0 | 1 | 7672 | 7,672 |
| Rock | 5570 | ton | 5 | 27850 | 25 | 139250 | 167,100 |
| Geotextile | 9000 | sf | 1 | 9000 | 1 | 9000 | 18,000 |
| Replace RCP storm drain | 480 | lf | 140 | 67200 | 530 | 254400 | 321,600 |
| Excavate/dispose of upland soil | 14000 | cy | 30 | 420000 | | | 420,000 |
| | | | | | | Subtotal: | 1,272,492 |
| **DREDGING LAURITZEN CANAL SEDIMENTS:** | | | | | | | |
| Mob/demob | 1 | ea | 100000 | | | | 100,000 |
| Dredging | 49000 | cy | 10 | 490000 | | | 490,000 |
| Clay/asphalt cap | 6200 | sy | 6 | 37200 | 6 | 37200 | 74,400 |
| Gravel/geotextile | 7000 | sy | 1 | 7000 | 5 | 35000 | 42,000 |
| Water quality monitoring | 1 | ea | 20000 | 20000 | 2000 | 2000 | 22,000 |
| Confirmation sampling plan | 1 | ea | 2000 | 2000 | 3000 | 3000 | 5,000 |
| Constr Drying Areas | 1 | ls | 5000 | | | | 5,000 |
| Conditioning Dredge Sediment | 28400 | cy | 2 | 44020 | 2 | 44020 | 88,040 |
| | | | | | | Subtotal: | 826,440 |

TABLE 4-4: ESTIMATED COSTS FOR ALTERNATIVE 4

| | Quantity | Unit | LABOR UNIT COST | LABOR Labor Cost | MATERIALS Unit Cost | MATERIALS Materials Cost | TOTAL COST |
|---|---|---|---|---|---|---|---|
| OTHER DIRECT CAPITAL COSTS: | | | | | | | |
| Modify Rail Cranes | 1 | ea | 100000 | 100000 | 100000 | 100000 | 200,000 |
| Install monitoring wells | 8 | ea | 1500 | 12000 | 500 | 4000 | 16,000 |
| | | | | | | Subtotal: | 216,000 |
| CAPITAL COSTS - INDIRECT: | | | | | | | |
| | | | | | | TOTAL DIRECT COSTS: | 8,942,418 |
| Engineering design | 0.10 * total direct | | | | | | 894,242 |
| Construction management | 0.15 * total direct | | | | | | 1,341,363 |
| | | | | | | TOTAL INDIRECT COSTS: | 2,235,605 |
| | | | | | | TOTAL CAPITAL (DIRECT & INDIRECT) | 11,178,023 |

TABLE 4-4: ESTIMATED COSTS FOR ALTERNATIVE 4

| | Quantity | Unit | LABOR UNIT COST | LABOR Labor Cost | MATERIALS Unit Cost | MATERIALS Materials Cost | TOTAL COST |
|---|---|---|---|---|---|---|---|
| ANNUAL MONITORING COSTS: | | | | | | | |
| Sediment sampling & analyses | 2 | ea | 2000 | 4000 | 4000 | 8000 | 12,000 |
| Biological sampling & anal | 1 | ea | 16000 | 16000 | 7500 | 7500 | 23,500 |
| Ground-water sampling & anal | 2 | ea | 2200 | 4400 | 2000 | 4000 | 8,400 |
| Inspect bulkhead and dam | 1 | ea | 20000 | 20000 | 1000 | 1000 | 21,000 |
| Monitoring reports | 2 | ea | 3000 | 6000 | 300 | 600 | 6,600 |
| | | | | | | Subtotal: | 71,500 |
| | | | | | | Present Worth (30 year term, 5% interest rate): | 785,532 |
| | | | | | | TOTAL PRESENT WORTH (Capital plus O&M costs): | 11,963,555 |

TABLE 4-5: ESTIMATED COSTS FOR ALTERNATIVE 5

| | Quantity | Unit | LABOR UNIT COST | LABOR Labor Cost | MATERIALS Unit Cost | MATERIALS Materials Cost | TOTAL COST |
|---|---|---|---|---|---|---|---|
| CAPITAL COSTS - DIRECT | | | | | | | |
| GRADING, CAPPING, DRAINAGE CONTROLS: | | | | | | | |
| Mob/demob | 1 | ea | | 5000 | | | 5,000 |
| Site prep | 1 | ea | 6000 | 6000 | | | 6,000 |
| Grading & compacting | 12,375 | sy | 2 | 24750 | 0 | 0 | 24,750 |
| Asphalt surface seal w/ AB | 24,750 | sy | | 0 | 12.00 | 297,000 | 297,000 |
| | | | | | | Subtotal: | 332,750 |
| EXCAVATE AND INCINERATE SOILS WITH >1000 PPM PESTICIDES: | | | | | | | |
| Mob/demob | 1 | ea | | 3000 | | | 3,000 |
| Pre-excavation sampling plan | 1 | ea | 4000 | 4000 | 20000 | 20000 | 24,000 |
| Site access preparations | 1 | ea | 10000 | 10000 | | | 10,000 |
| Excavate affected material | 2000 | cy | 25 | 50000 | | | 50,000 |
| Confirmation sampling plan | 1 | ea | 2000 | 2000 | 20000 | 20000 | 22,000 |
| Backfill excavation | 1500 | cy | 5 | 7500 | 10 | 15000 | 22,500 |
| Air monitoring | 1 | ea | 9000 | 9000 | 3000 | 3000 | 12,000 |
| Transport soils offsite | 2000 | cy | 200 | 400000 | | | 400,000 |
| Soil incineration | 2000 | cy | 1500 | 3000000 | | | 3,000,000 |
| Ca Superfund tax | 1600 | ton | 21 | 33600 | | | 33,600 |
| | | | | | | Subtotal: | 3,577,100 |

TABLE 4-5: ESTIMATED COSTS FOR ALTERNATIVE 5

| | Quantity | Unit | LABOR UNIT COST | LABOR Labor Cost | MATERIALS Unit Cost | MATERIALS Materials Cost | TOTAL COST |
|---|---|---|---|---|---|---|---|
| CONSTRUCTION OF SHEET PILE BULKHEAD: | | | | | | | |
| Mob/Demob | 1 | ea | 5000 | 5000 | | | 5,000 |
| Arbed sheet pile sections | 1,155 | lf | 350 | 404250 | 2532 | 2,924,460 | 3,328,710 |
| Tie rods | 1,155 | lf | 184 | 212231 | 551 | 636,694 | 848,925 |
| HP piles (12x63) | 1,155 | 12 lf | 154 | 178274 | 222 | 256,710 | 434,985 |
| HP piles (12x53) | 1,155 | 12 lf | 154 | 178274 | 374 | 431,935 | 610,210 |
| Concrete deadmen | 635 | cy | | 0 | 400 | 254,000 | 254,000 |
| Painting steel sheets | 57750 | sf | 1 | 43313 | 1 | 43,313 | 86,625 |
| Cathodic Protection | 1155 | lf | | | 50 | 57,750 | 57,750 |
| Wales | 1155 | lf | 13 | 14438 | 38 | 43,313 | 57,750 |
| Geotextile backing | 1155 | lf | 23 | 25988 | 23 | 25,988 | 51,975 |
| Remove and replace fenders | 1155 | lf | 200 | 231000 | | | 231,000 |
| Reinforced concrete cap | 1155 | lf | 400 | 462000 | 400 | 462,000 | 924,000 |
| | | | | | | Subtotal: | 6,890,929 |
| DREDGING & OFFSITE DISPOSAL OF LAURITZEN CANAL SEDIMENTS: | | | | | | | |
| Mob/demob | 1 | ea | 100000 | | | | 100,000 |
| Dredging | 57000 | cy | 10 | 570000 | | | 570,000 |
| Gravel/geotextile cap | 7000 | sy | 1 | 7000 | 5 | 35000 | 42,000 |
| Water quality monitoring | 1 | ea | 20000 | 20000 | 2000 | 2000 | 22,000 |
| Confirmation sampling plan | 1 | ea | 2000 | 2000 | 3000 | 3000 | 5,000 |
| Constr Drying Areas | 1 | ls | 5000 | | | | 5000 |
| Conditioning Dredge Sediment | 36000 | cy | 5 | 180000 | 2 | 55800 | 235800 |
| Offsite land disposal | 36000 | cy | 225 | 8100000 | | | 8100000 |
| Ca disposal fee & tax | 50400 | ton | 42 | 2116800 | | | 2116800 |
| Ca generator fee | 50400 | ton | 55120 | | | | 55120 |
| | | | | | | Subtotal: | 11,251,720 |

TABLE 4-5: ESTIMATED COSTS FOR ALTERNATIVE 5

| | Quantity | Unit | LABOR UNIT COST | Labor Cost | MATERIALS Unit Cost | Materials Cost | TOTAL COST |
|---|---|---|---|---|---|---|---|
| **OTHER DIRECT CAPITAL COSTS:** | | | | | | | |
| Modify Rail Cranes | 1 | ea | 100000 | 100000 | 100000 | 100000 | 200000 |
| Install monitoring wells | 8 | ea | 1500 | 12000 | 500 | 4000 | 16000 |
| | | | | | | Subtotal: | 216000 |
| **CAPITAL COSTS - INDIRECT:** | | | | | | | |
| | | | | | | TOTAL DIRECT COSTS: | 22268499 |
| Engineering design | 0.04 * total direct | | | | | | 890,740 |
| Construction management | 0.04 * total direct | | | | | | 1,558,795 |
| | | | | | | TOTAL INDIRECT COSTS: | 2,449,535 |
| | | | | | | TOTAL CAPITAL (DIRECT & INDIRECT) | 24,718,034 |
| **ANNUAL MONITORING COSTS:** | | | | | | | |
| Sediment sampling & analyses | 2 | ea | 2000 | 4000 | 4000 | 8000 | 12,000 |
| Biological sampling & analys | 1 | ea | 16000 | 16000 | 7500 | 7500 | 23,500 |
| Ground-water sampling & anal | 2 | ea | 2200 | 4400 | 2000 | 4000 | 8,400 |
| Inspect bulkhead and dam | 1 | ea | 21000 | 21000 | 4000 | 4000 | 25,000 |
| Monitoring reports | 2 | ea | 10000 | 10000 | 1000 | 1000 | 11,000 |
| | | | | | | Subtotal: | 79,900 |
| | | | | | | Present Worth (30 year term, 5% interest rate): | 785,532 |
| | | | | | | TOTAL PRESENT WORTH (Capital plus O&M costs): | 25,503,566 |

TAB!E 4-6: COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

| Description of Alternative | Short-Term Effectiveness | Long-Term Effectiveness and Permanence | Reduction in Toxicity, Mobility, and Volume through Treatment | Implementability | Cost (Estimated Present Worth) | Compliance with ARARs | Overall Protection of Human Health & the Environment |
|---|---|---|---|---|---|---|---|
| Alternative 1: No Action | Not Applicable No remediation performed | Not effective | No reduction | Implementable | $1,250,000 | Would comply | Would not reduce existing health or environmental risks |
| Alternative 2: On-site capping and drainage drainage controls. Shoreline stabilization with bulkhead. On-site containment of dredged sediments behind bulkhead. Environ. monitoring and institutional controls. | Low short-term risks, 48,000 cu. yd. of sediment dredged from Canal | Effective. Expected design life of bulkhead is >100 years with proper construction and maintenance. | Reduction in mobility achieved through containment. | Implementable using available equipment, labor, & construction techniques. Would create 1.8 ac. of fill. May require mitigation and significant interagency coordination, and possible agreements with adjacent property owners. | $12,000,000 | Expected to meet ARARs. | Expected to adequately protect human health and environment. |
| Alternative 3: Same as Alternative 2 except that dredged sediments also contained behind dam. | Very low short-term risks, 38,000 cu. yd. of sediment dredged from Canal. | Same as Alternative 2, except rock dam would be very permanent structure & would require minimal maintenance. | Same as Alternative 2 | Same as Alternative 2, would create 2.6 ac. of fill. | $8,940,000 | Expected to meet ARARs. | Expected to adequately protect human health & environment. |
| Alternative 4: Same as Alternative 3 except that dredged sediments also contained in upland area behind dam. | Moderate short-term risks, 49,000 cu. yd. of sediment dredged. Sediments dried on site. | Same as Alternative 3 | Same as Alternative 2 | Same as Alternative 3, would create 1.7 ac. of fill. | $11,960,000 | Expected to meet ARARs. | Expected to adequately protect human health & environment. |
| Alternative 5: Same as Alternative 2 except that soils with pesticide concentrations >1000 ppm treated/disposed of off site. Most offshore sediments disposed at off-site facility. | High short-term risks, 57,000 cu. yd. of sediment dredged. 36,000 cu. yd. of sediment dried and hauled off site. | Same as Alternative 2 | Reduction in toxicity, mobility, and volume achieved by incineration of soils with highest pesticide concentrations. | Same as Alternative 2, would create 1.4 ac. of fill. | $25,504,000 | Expected to meet ARARs. | Expected to adequately protect human health & environment. |

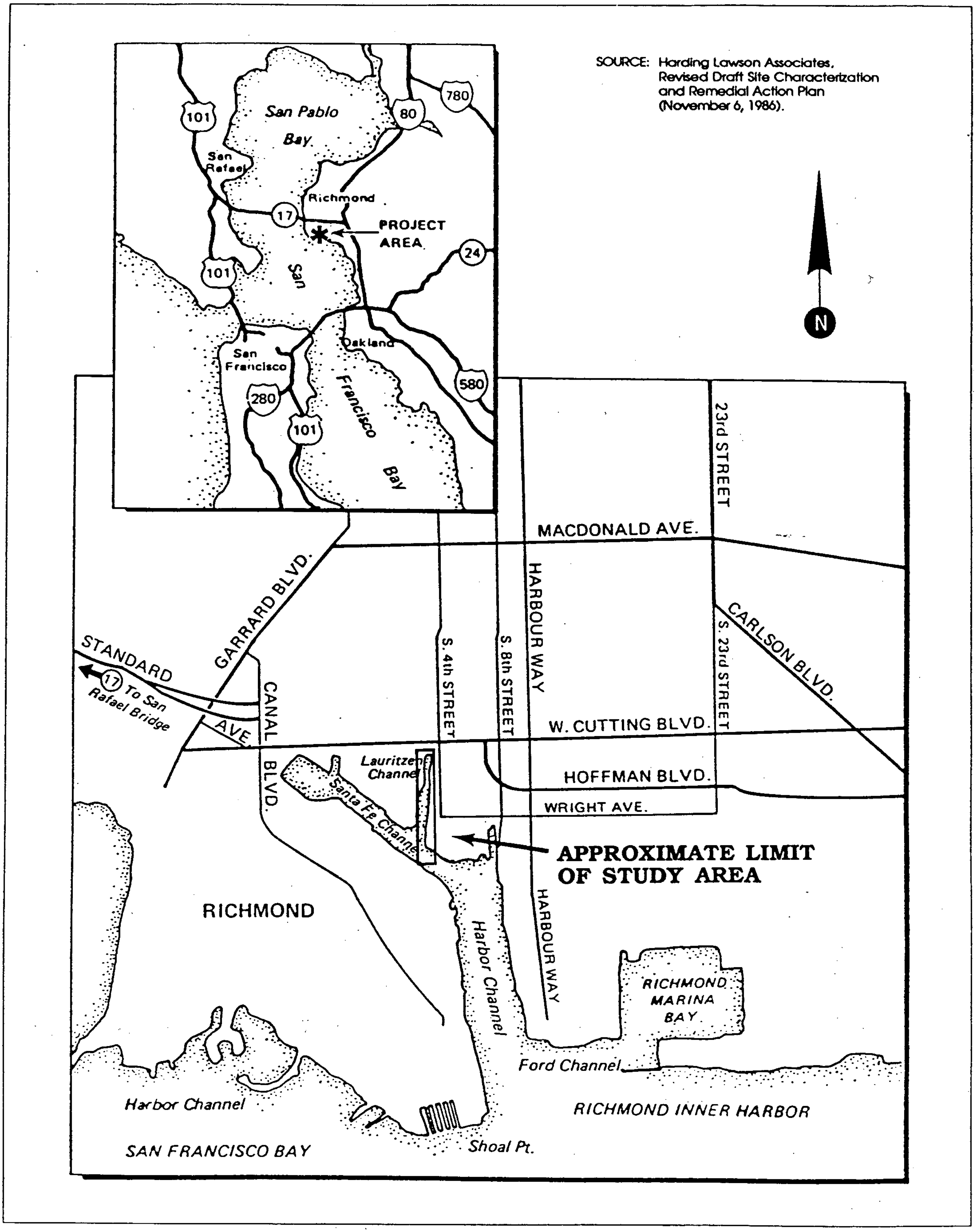



Figure 1-1 : SITE LOCATION MAP

123957

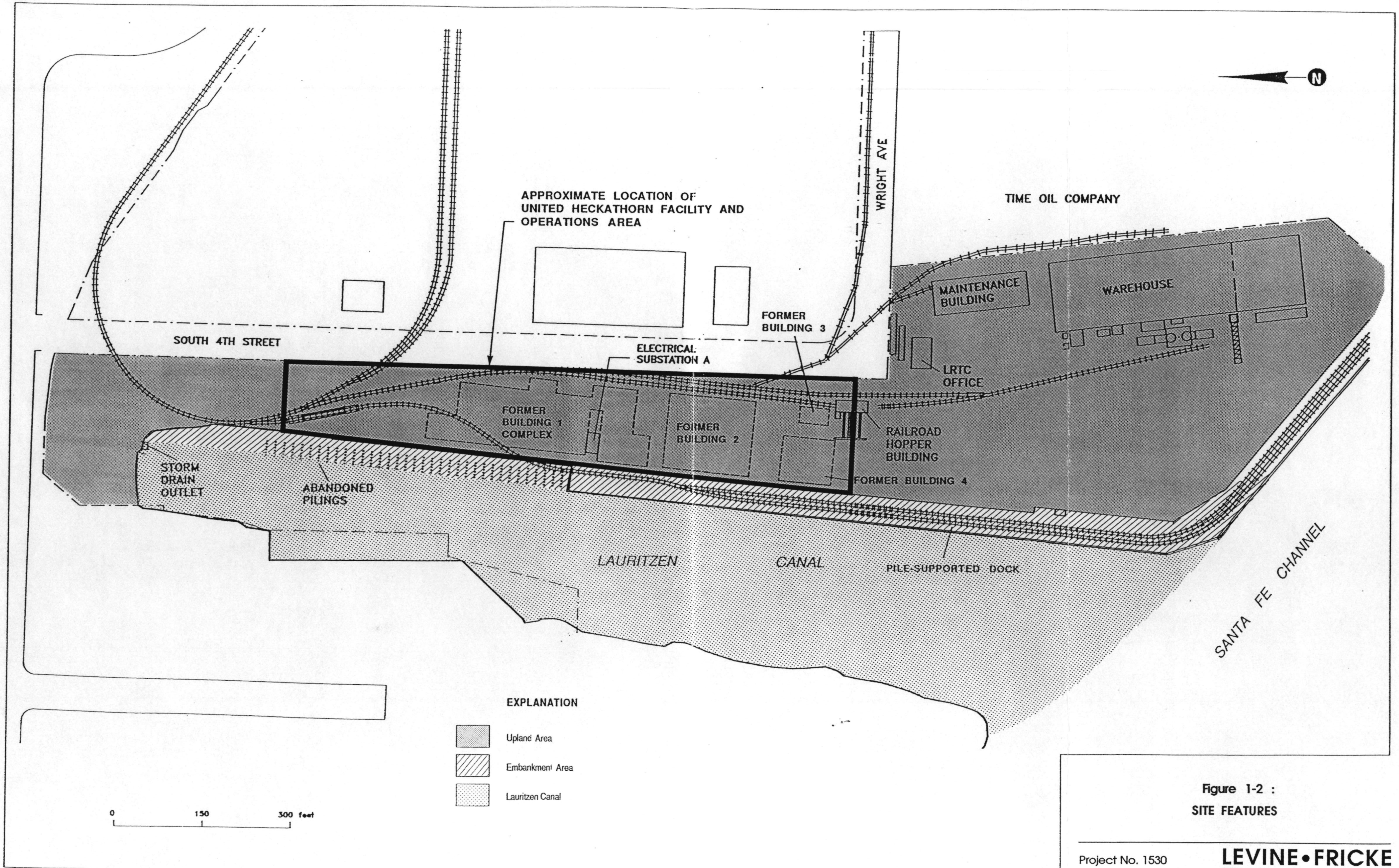



**Figure 1-2 :**

**SITE FEATURES**

Project No. 1530

LEVINE • FRICKE
CONSULTING ENGINEERS AND HYDROGEOLOGISTS

ALL31DEC90mp

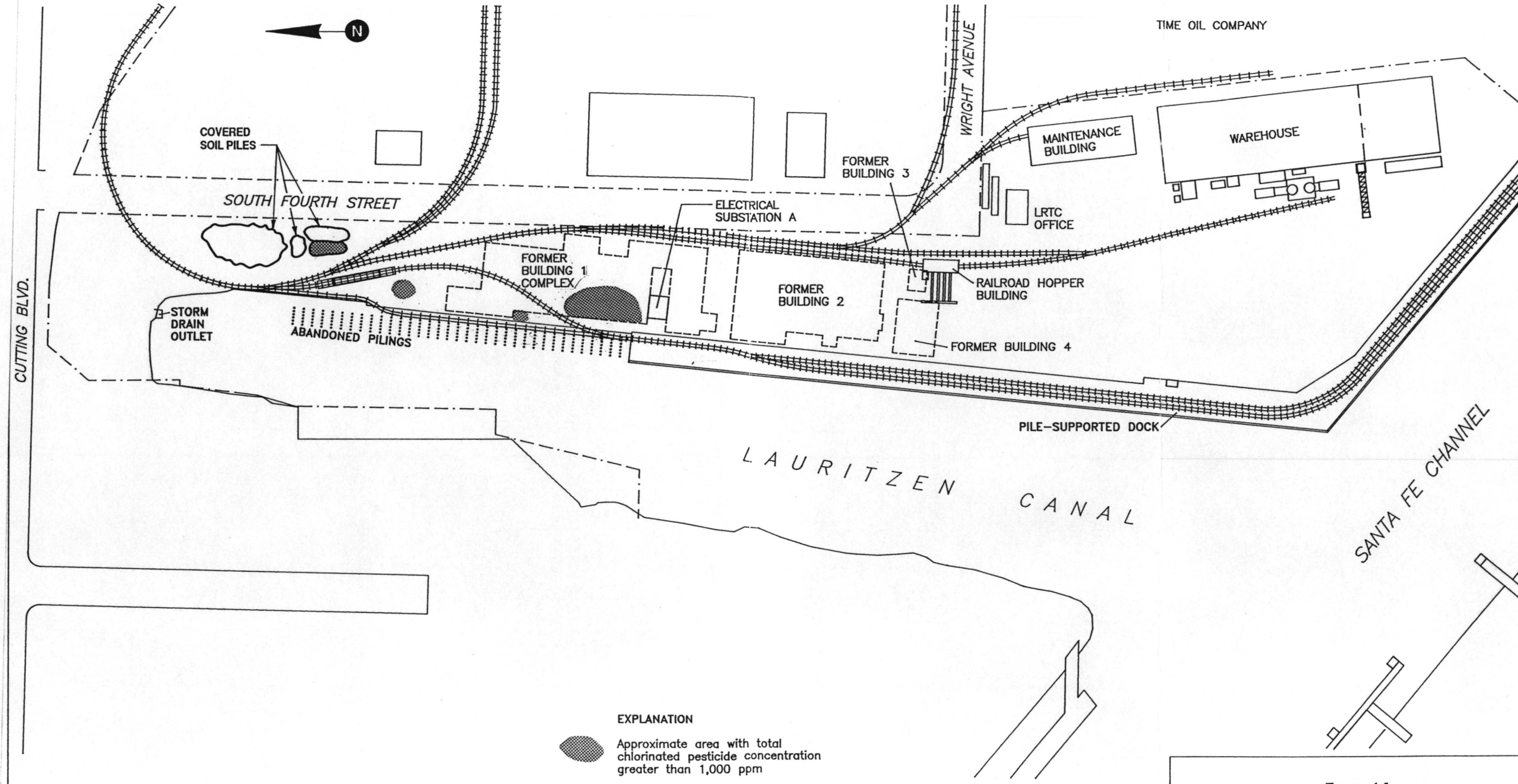



**Figure 4-1 :**

**UPLAND SOILS WITH ELEVATED PESTICIDE CONCENTRATIONS**

Project No. 1530

**LEVINE • FRICKE**
CONSULTING ENGINEERS AND HYDROGEOLOGISTS

1530\B2MR16.ALL90DAT 1:150

ALL02JAN91

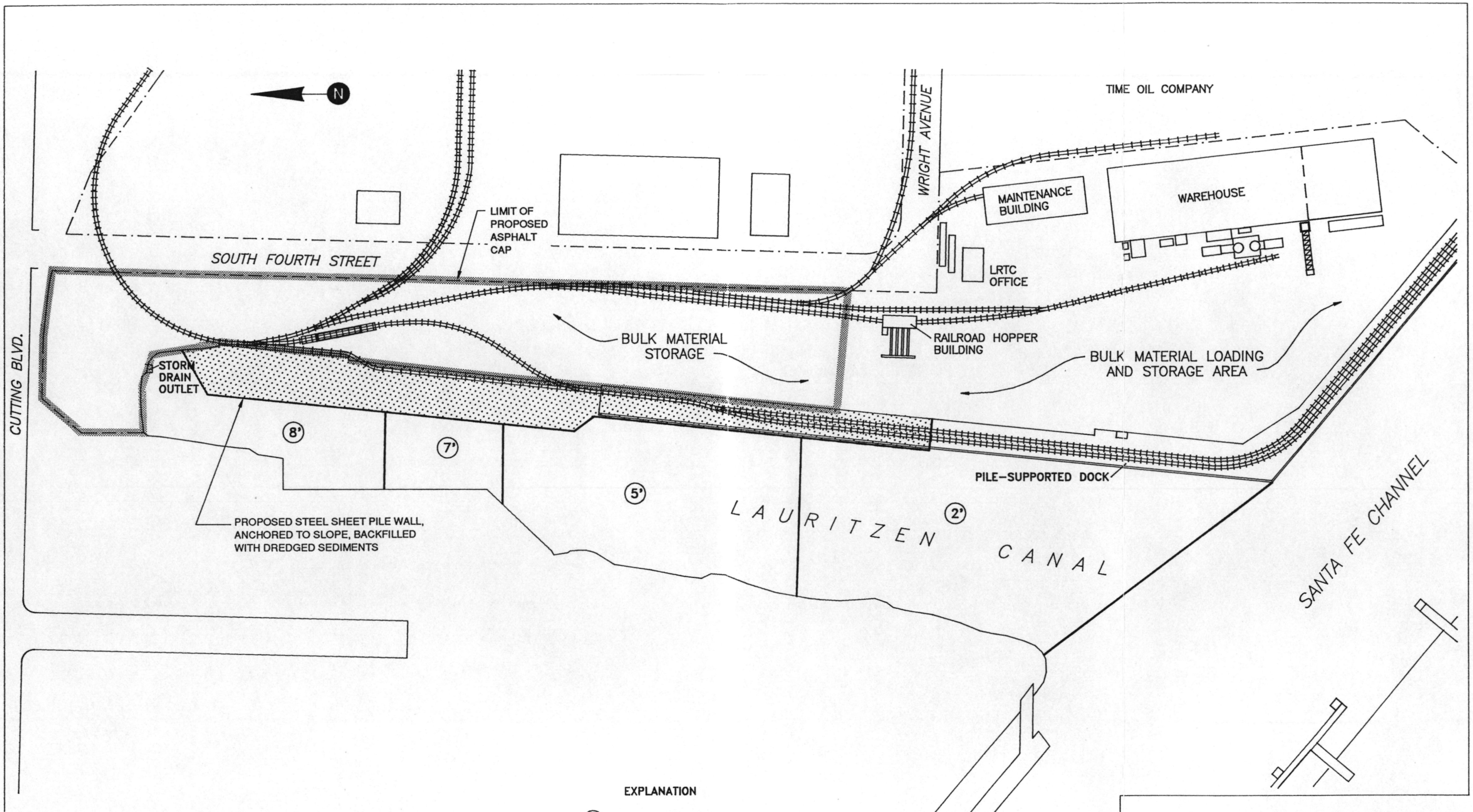



Figure 4-2 :
UNITED HECKATHORN FEASIBILITY STUDY
ALTERNATIVE 2

Project No. 1530

LEVINE•FRICKE
CONSULTING ENGINEERS AND HYDROGEOLOGISTS

1530\ALTSMY29.JCS90DAT 1:150

ALL13AUG90DTA

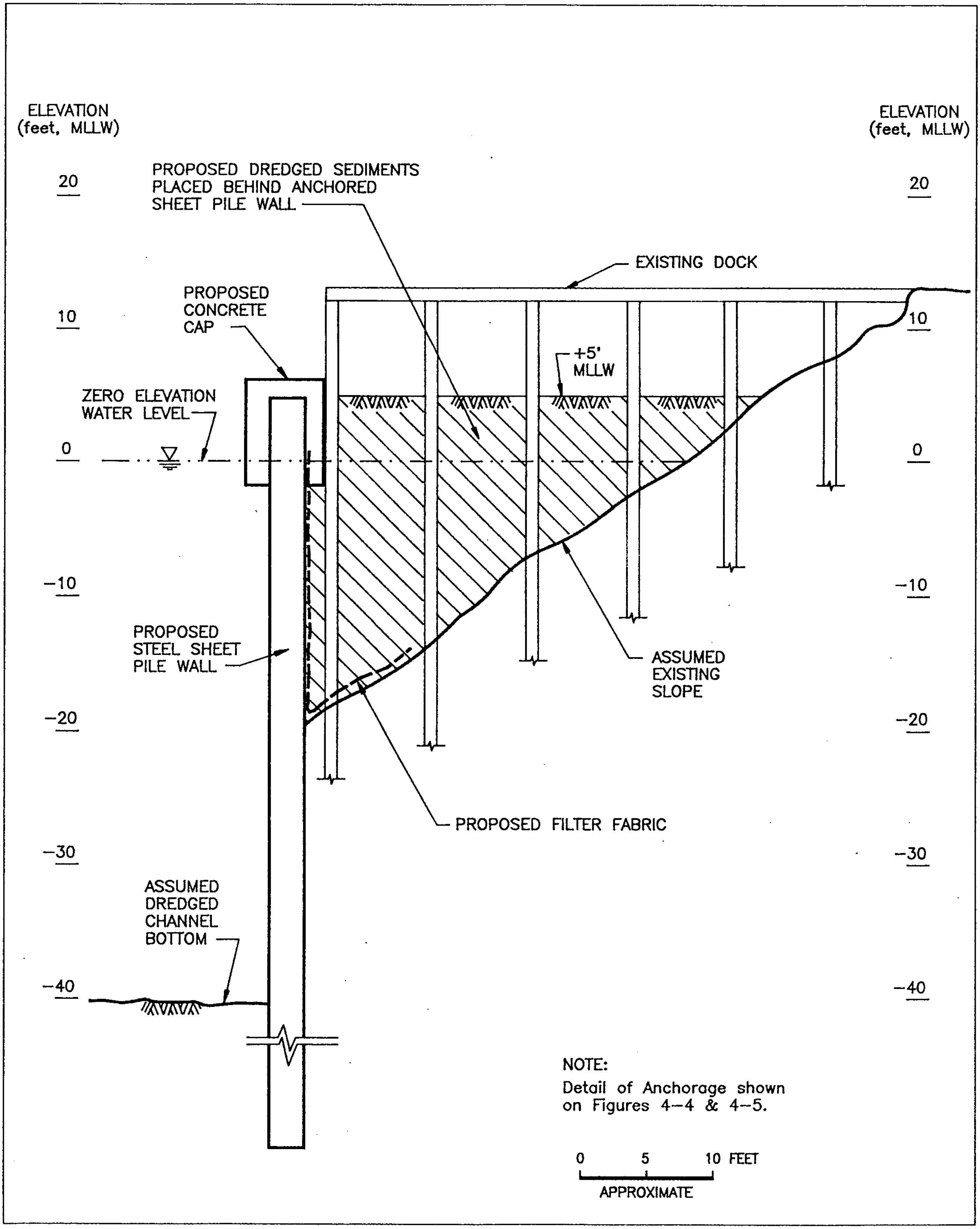



**Figure 4-3 : TYPICAL CROSS SECTION OF THE EAST BANK OF THE LAURITZEN CANAL SHOWING PROPOSED ANCHORED BULKHEAD AND DOCK**

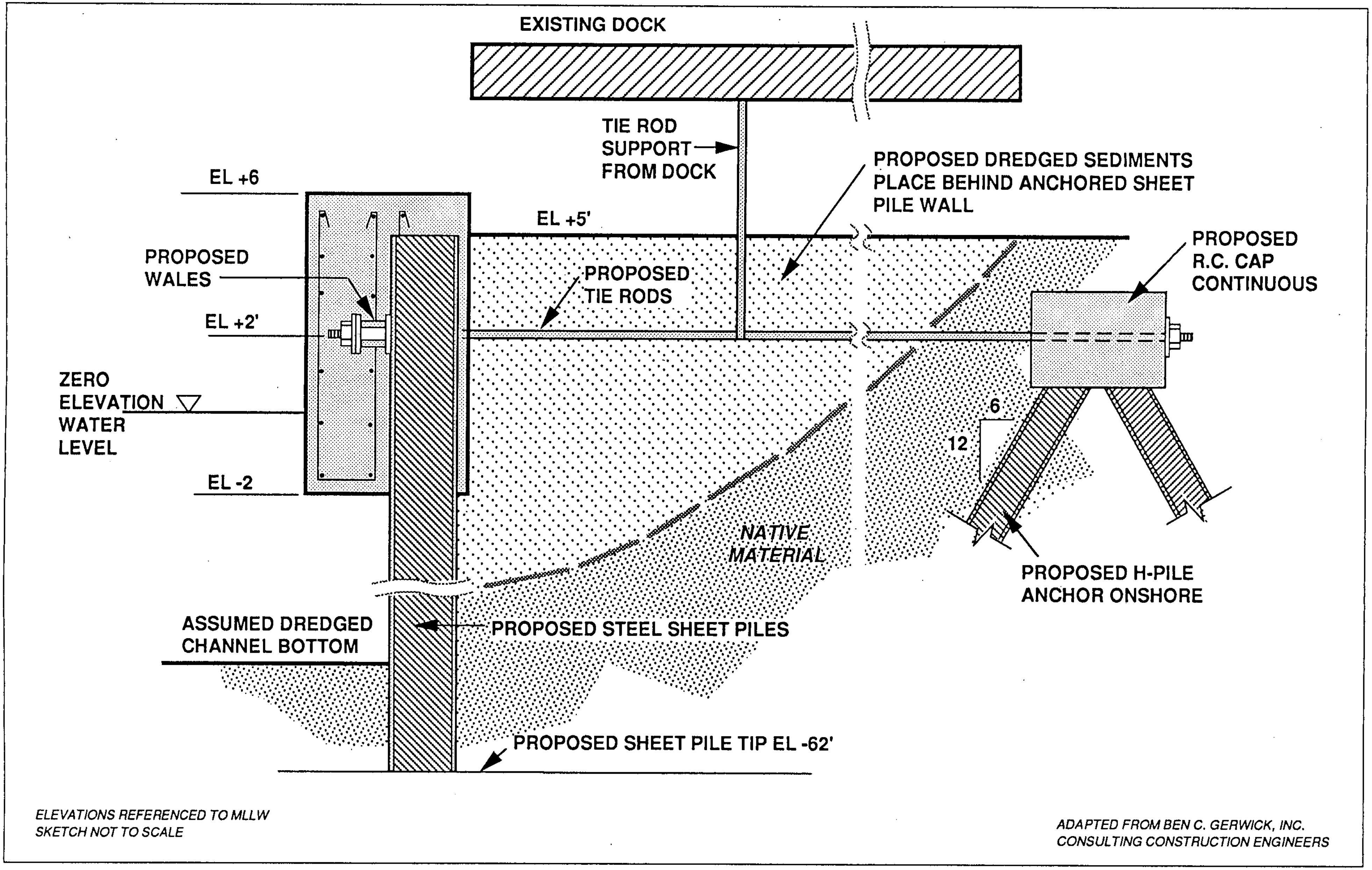



**Figure 4-4 : CROSS SECTION OF PROPOSED ANCHORED BULKHEAD ALONG WHARF**

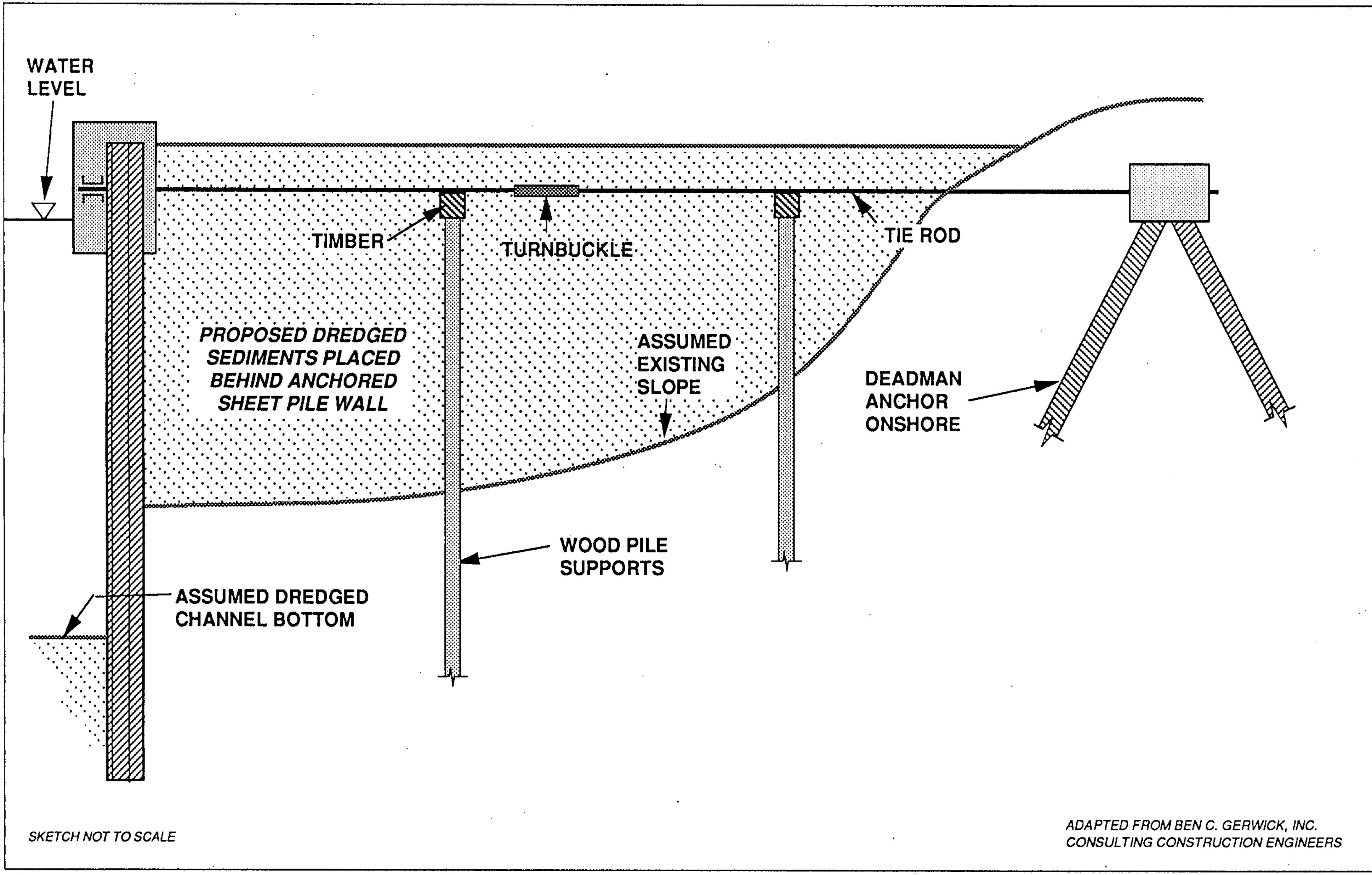
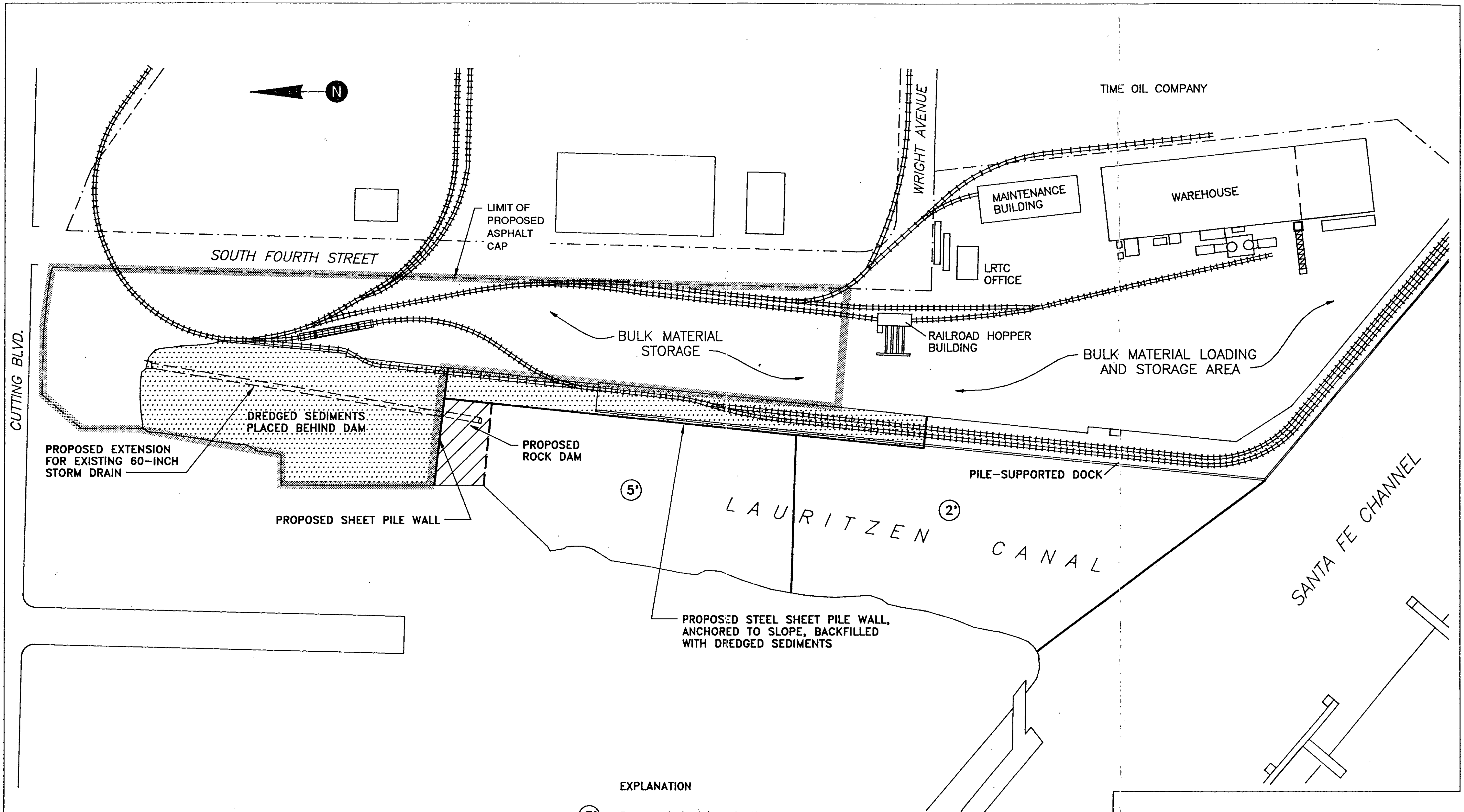



**Figure 4-5 : CROSS SECTION OF PROPOSED ANCHORED BULKHEAD FOR ALTERNATIVE 2 (NORTH OF EXISTING WHARF)**




**EXPLANATION**

(5') Proposed dredging depth of approximately 5 feet

0 50 100 150 FEET

**Figure 4-6 :**

**UNITED HECKATHORN FEASIBILITY STUDY ALTERNATIVE 3**

Project No. 1530

**LEVINE•FRICKE**
CONSULTING ENGINEERS AND HYDROGEOLOGISTS

1530\ALTSMY29.JCS90DAT 1:150

ALL13AUG90DTA

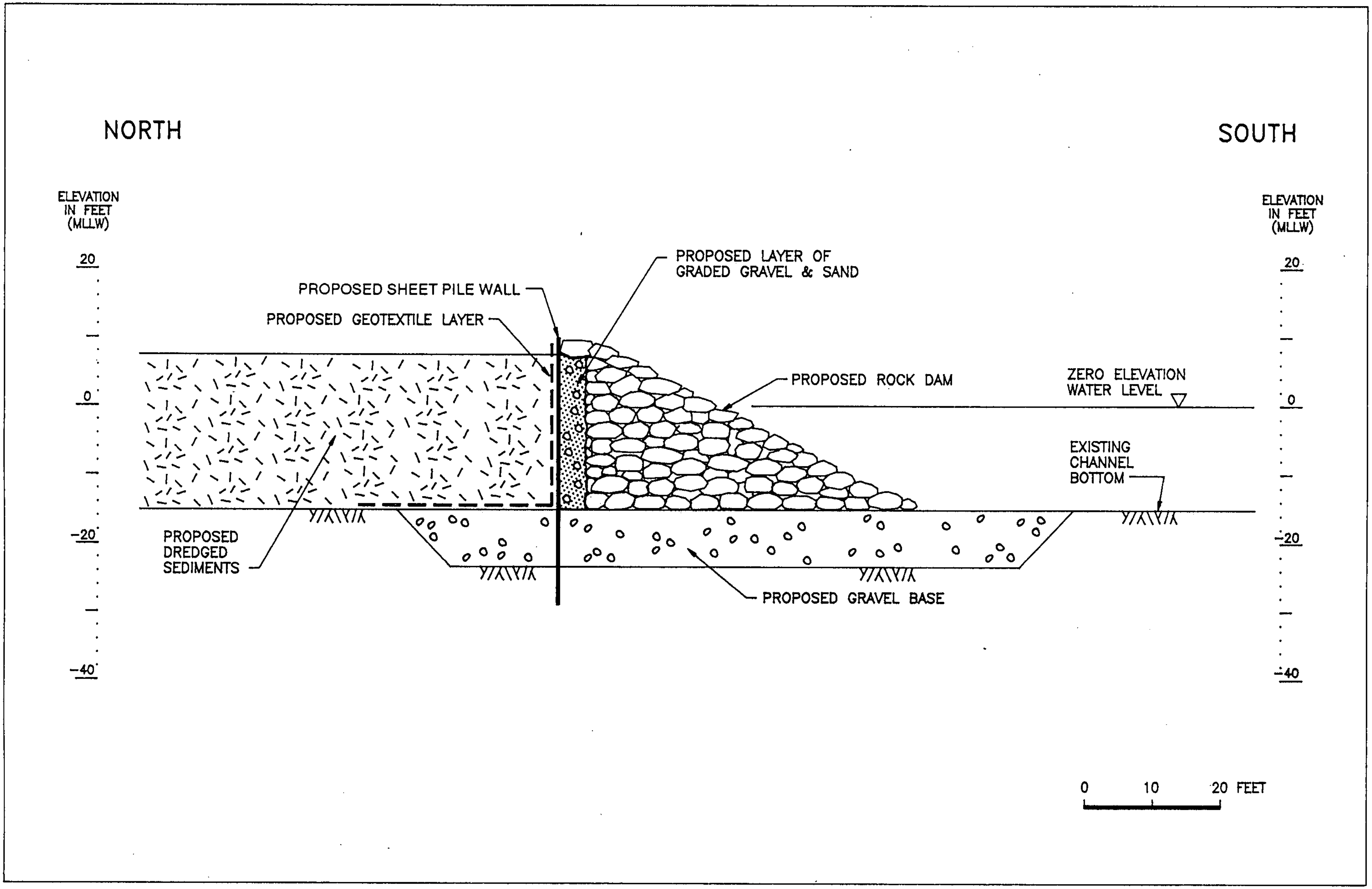



Figure 4-7 : CROSS SECTION OF PROPOSED ROCK DAM - SHEET PILE WALL

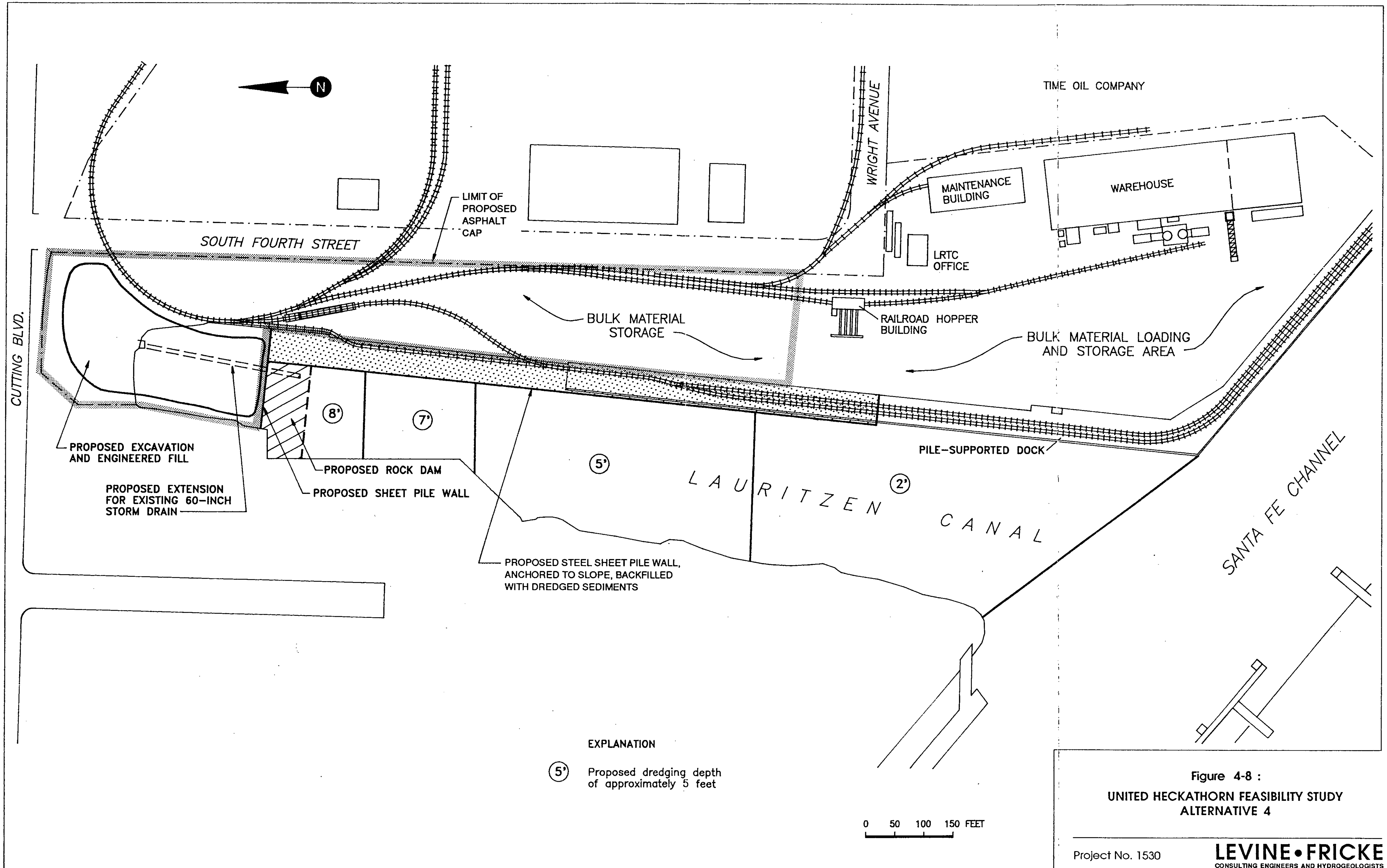



**Figure 4-8 :**
**UNITED HECKATHORN FEASIBILITY STUDY**
**ALTERNATIVE 4**

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1530\ALTSMY29.JCS90DAT 1:150

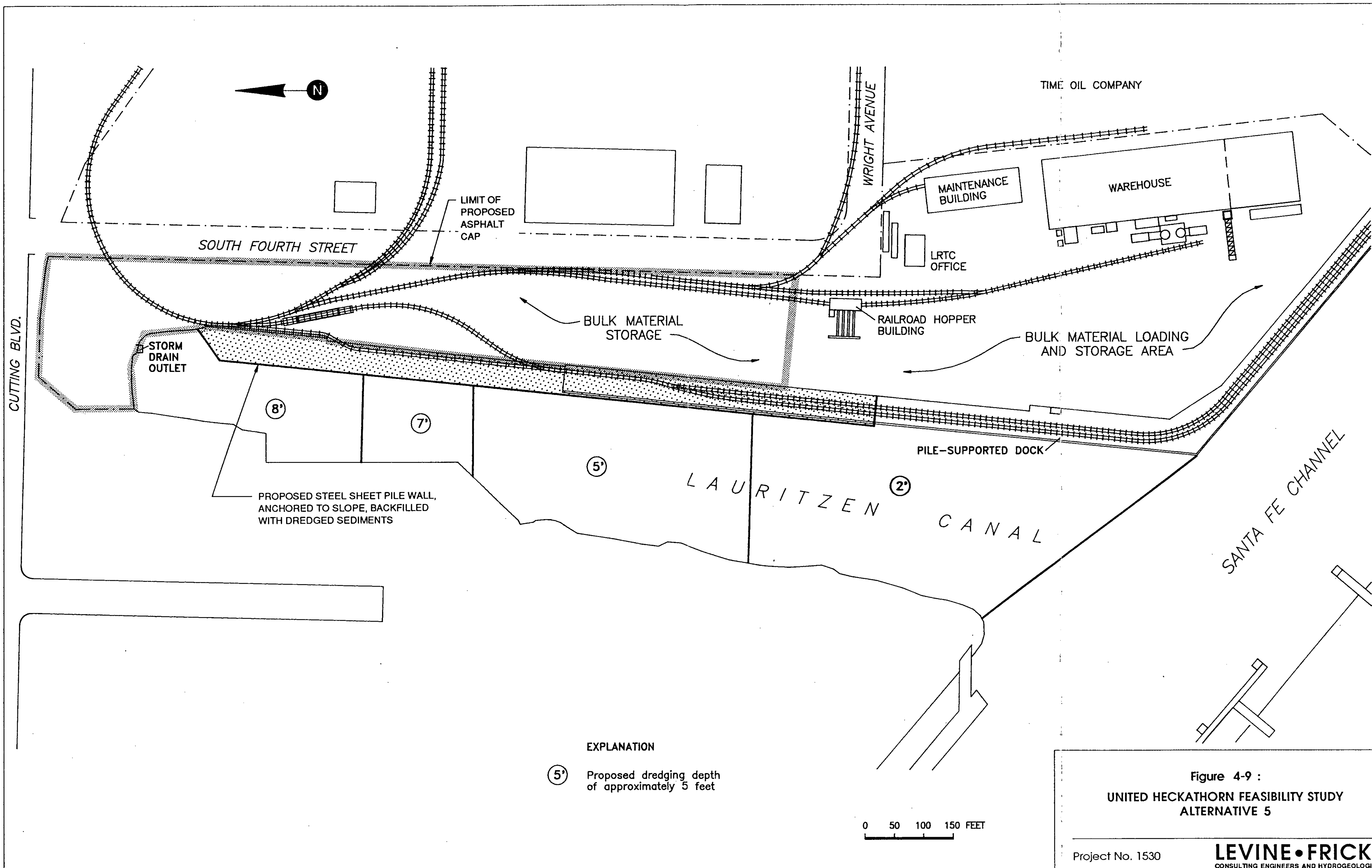



**Figure 4-9 :**

**UNITED HECKATHORN FEASIBILITY STUDY**
**ALTERNATIVE 5**

Project No. 1530

**LEVINE•FRICKE**
CONSULTING ENGINEERS AND HYDROGEOLOGISTS

ALL13AUG90DTA

1530\ALTSMY29.JCS90DAT 1:150

# APPENDIX A

# STABR ANALYSES AND GEOTECHNICAL DATA

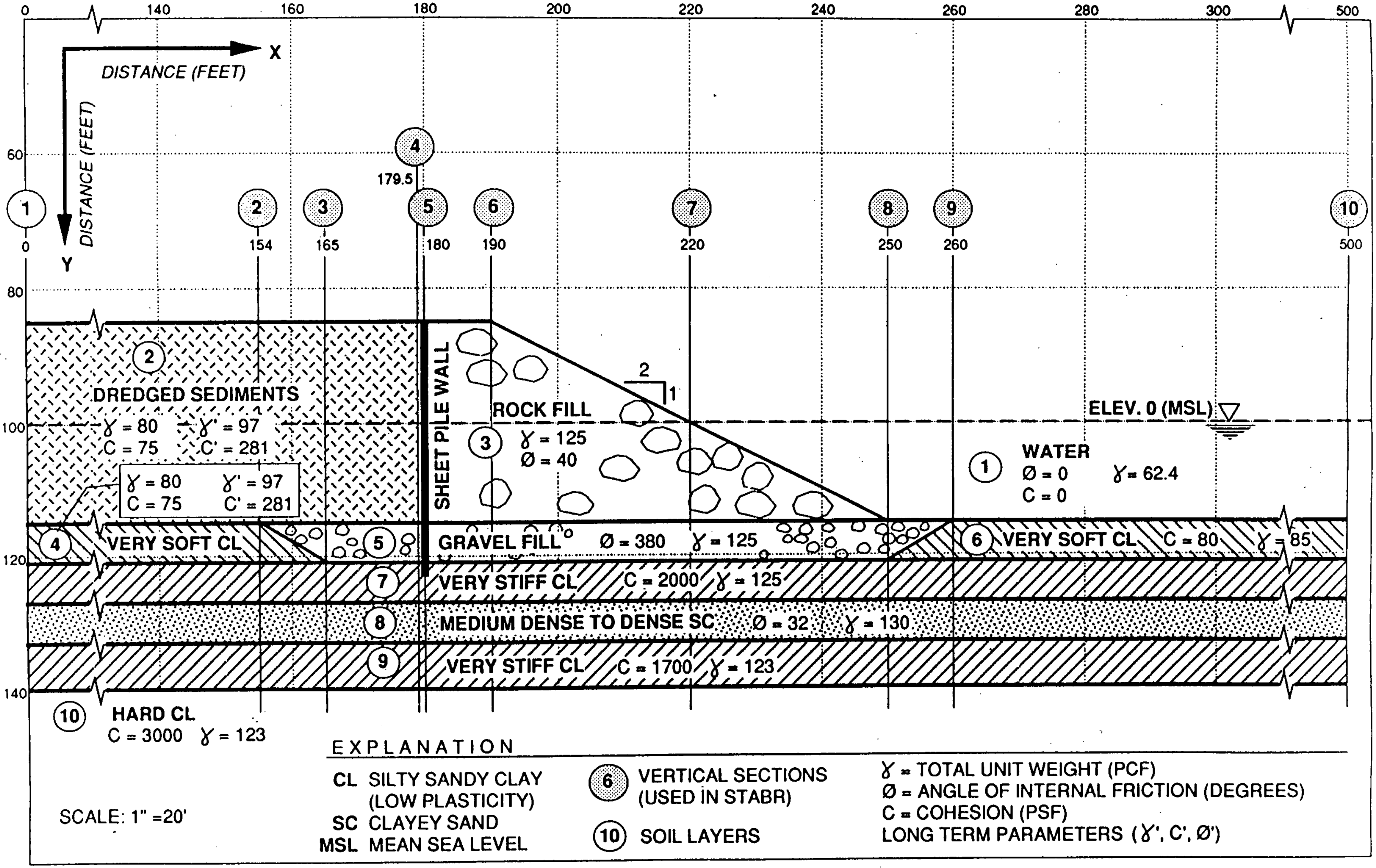
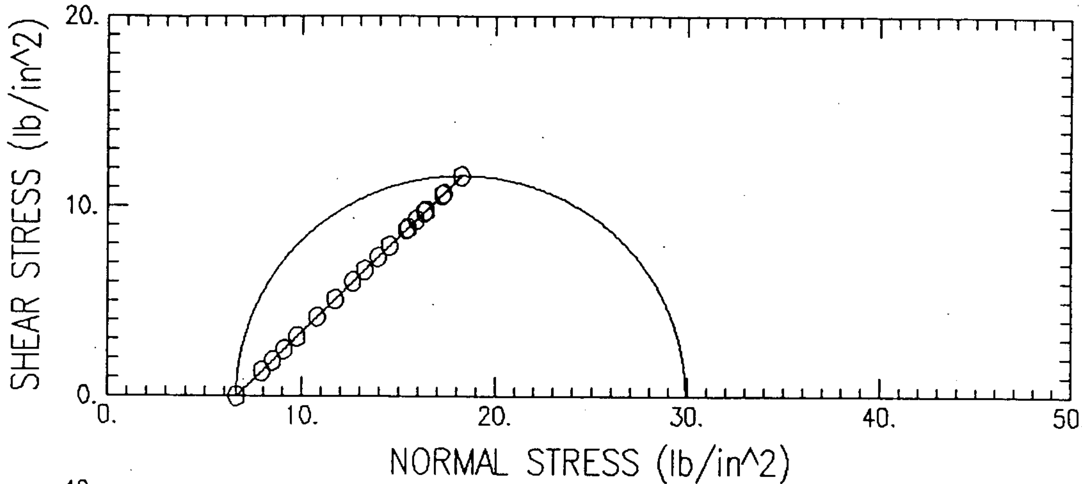
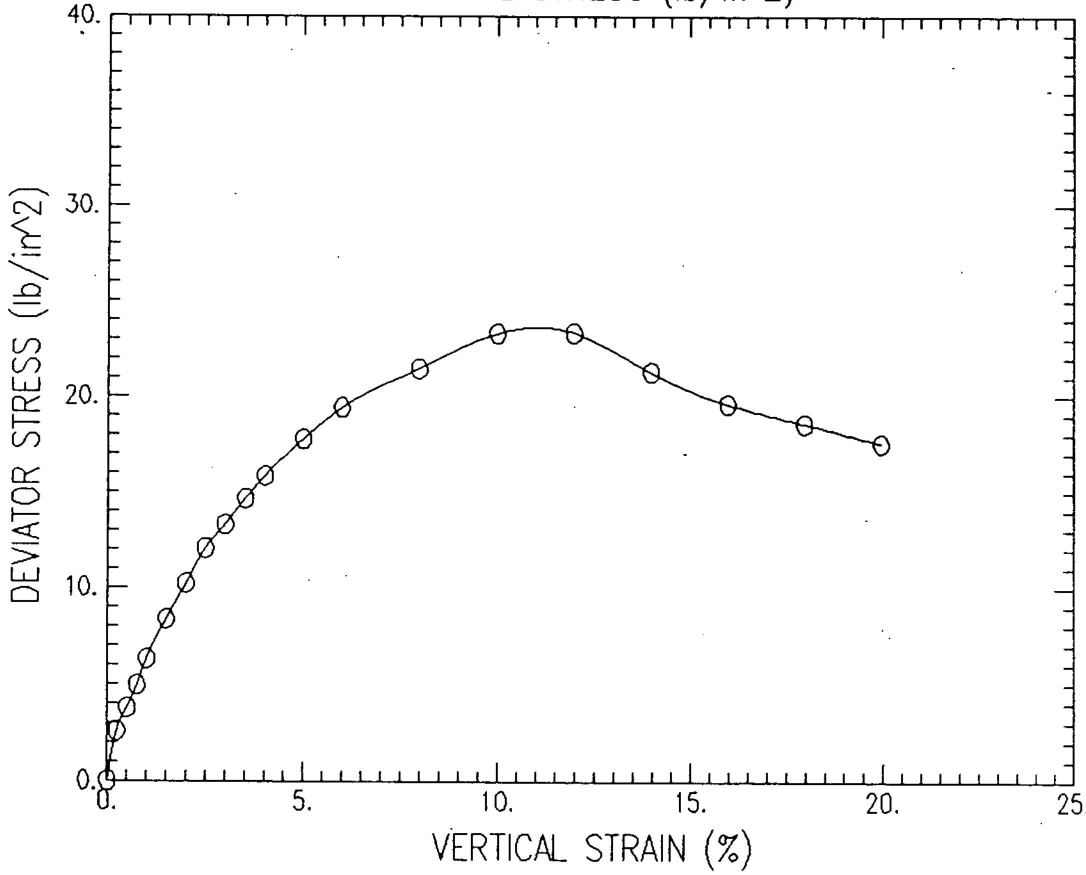



**Figure : SLOPE CONFIGURATION FOR COMPUTER (STABR) SLOPE STABILITY ANALYSES**

UNDRAINED TRIAXIAL TEST




| Project Name : LEVINE-FRICKE LRTC #1530 | | | | Location : |
|---|---|---|---|---|
| Boring No: | Sample No | Depth | Test No | Filename |
| LC2-6 | LC2-6/24 | | LC2-6/24 | LC2624 |

# UNDRAINED TRIAXIAL COMPRESSION TEST

Project : LEVINE-FRICKE LRTC #1530 Location :
Project No. : 16148A Test No. : LC2-6/24
Boring No. : LC2-6 Test Date : 2/9/90 Tested by : C. WASON
Sample No. : LC2-6/24 Depth : Checked by : S. CAPPS
Soil Description : LT. GREENISH GRAY SILTY CLAY

Height : 4.020 (in) Piston Diameter : 0.000 (in) Filter Correction : 0.00 (lb/in^2)
Area : 2.96 (in^2) Piston Friction : 0.00 (lb) Membrane Correction : 0.00 (lb/in)
Volume : 11.88 (in^3) Piston Weight : 0.00 (gm) Area Correction : Parabolic

| | CHANGE IN LENGTH (in) | VERTICAL STRAIN (%) | CORR. AREA (in^2) | PORE PRESSURE (lb/in^2) | DEV. LOAD (lb) | CORR. DEV. LOAD (lb) | DEV. STRESS (lb/in^2) | TOTAL VERTICAL STRESS (lb/in^2) | EFFECTIVE VERTICAL STRESS (lb/in^2) |
|---|---|---|---|---|---|---|---|---|---|
| 1) | 0.000 | 0.00 | 2.96 | 0.00 | 0.00 | 0.00 | 0.00 | 6.60 | 6.60 |
| 2) | 0.010 | 0.25 | 2.97 | 0.00 | 7.67 | 7.67 | 2.58 | 9.18 | 9.18 |
| 3) | 0.020 | 0.50 | 2.98 | 0.00 | 11.21 | 11.21 | 3.76 | 10.36 | 10.36 |
| 4) | 0.030 | 0.75 | 2.99 | 0.00 | 14.75 | 14.75 | 4.93 | 11.53 | 11.53 |
| 5) | 0.040 | 1.00 | 3.01 | 0.00 | 18.88 | 18.88 | 6.28 | 12.88 | 12.88 |
| 6) | 0.060 | 1.49 | 3.03 | 0.00 | 25.37 | 25.37 | 8.37 | 14.97 | 14.97 |
| 7) | 0.080 | 1.99 | 3.06 | 0.00 | 31.27 | 31.27 | 10.23 | 16.83 | 16.83 |
| 8) | 0.100 | 2.49 | 3.08 | 0.00 | 37.17 | 37.17 | 12.05 | 18.65 | 18.65 |
| 9) | 0.120 | 2.99 | 3.11 | 0.00 | 41.30 | 41.30 | 13.28 | 19.88 | 19.88 |
| 10) | 0.141 | 3.51 | 3.14 | 0.00 | 46.02 | 46.02 | 14.66 | 21.26 | 21.26 |
| 11) | 0.161 | 4.00 | 3.17 | 0.00 | 50.15 | 50.15 | 15.83 | 22.43 | 22.43 |
| 12) | 0.201 | 5.00 | 3.22 | 0.00 | 57.23 | 57.23 | 17.75 | 24.35 | 24.35 |
| 13) | 0.241 | 6.00 | 3.28 | 0.00 | 63.72 | 63.72 | 19.40 | 26.00 | 26.00 |
| 14) | 0.321 | 7.99 | 3.41 | 0.00 | 73.16 | 73.16 | 21.46 | 28.06 | 28.06 |
| 15) | 0.402 | 10.00 | 3.55 | 0.00 | 82.60 | 82.60 | 23.29 | 29.89 | 29.89 |
| 16) | 0.482 | 11.99 | 3.69 | 0.00 | 86.14 | 86.14 | 23.32 | 29.92 | 29.92 |
| 17) | 0.562 | 13.98 | 3.85 | 0.00 | 82.01 | 82.01 | 21.28 | 27.88 | 27.88 |
| 18) | 0.643 | 16.00 | 4.03 | 0.00 | 79.06 | 79.06 | 19.62 | 26.22 | 26.22 |
| 19) | 0.723 | 17.99 | 4.22 | 0.00 | 78.47 | 78.47 | 18.59 | 25.19 | 25.19 |
| 20) | 0.803 | 19.98 | 4.43 | 0.00 | 77.88 | 77.88 | 17.58 | 24.18 | 24.18 |

UNDRAINED TRIAXIAL COMPRESSION TEST

Project : LEVINE-FRICKE LRTC #1530
Project No. : 16148A
Boring No. : LC2-6
Sample No. : LC2-6/24
Soil Description : LT. GREENISH GRAY SILTY CLAY

Location :
Test No. : LC2-6/24
Test Date : 2/9/90
Depth :

Tested by : C. WASON
Checked by : S. CAPPS

| | WATER CONTENT | | |
|---|---|---|---|
| | BEFORE TEST | AFTER TEST | TRIMMINGS |
| CONTAINER NO. | | | |
| WT CONTAINER + WET SOIL (gm) | 383.90 | 0.00 | 0.00 |
| WT CONTAINER + DRY SOIL (gm) | 306.00 | 0.00 | 0.00 |
| WT WATER (gm) | 77.90 | 0.00 | 0.00 |
| WT CONTAINER (gm) | 0.00 | 0.00 | 0.00 |
| WT DRY SOIL (gm) | 306.00 | 0.00 | 0.00 |
| WATER CONTENT (%) | 25.46 | 0.00 | 0.00 |

| | INITIAL | AT CONSOLIDATION |
|---|---|---|
| WATER CONTENT (%) | 25.46 | 25.46 |
| VOID RATIO | 0.74 | 0.74 |
| WET DENSITY (lb/ft^3) | 123.07 | 123.07 |
| DRY DENSITY (lb/ft^3) | 98.10 | 98.10 |
| DEGREE OF SATURATION (%) | 94.36 | 94.36 |

Maximum Shear Stress = 11.66 (lb/in^2) at a Vertical Strain of 11.99 %

File # LC 2624 U U - TRIAXIAL TEST DATA

PROJECT NAME LEVINE-FRICKE #1530 PROJECT NO. 16148A

SAMPLE NO. LC2 - 6/24 DATE 2/9/90

DESCRIPTION Lt. greenish gray - silty clay

TESTED BY C. Wilson REDUCED BY C. Wilson CHECKED BY S Capps

DIAM$_o$ 1.94" = cm. AREA$_o$ 19.07 cm.$^2$ HEIGHT$_o$ 4.02" = 10.2 cm.

2.956 IN$^2$

WET WT. BEFORE TEST 383.90 gms. WATER CONT. B.T. 25.46 %

DRY WT. AFTER TEST 306.00 gms. $\sigma_{3c}$ 6.6 PSI = 0.464 kgs/cm$^2$

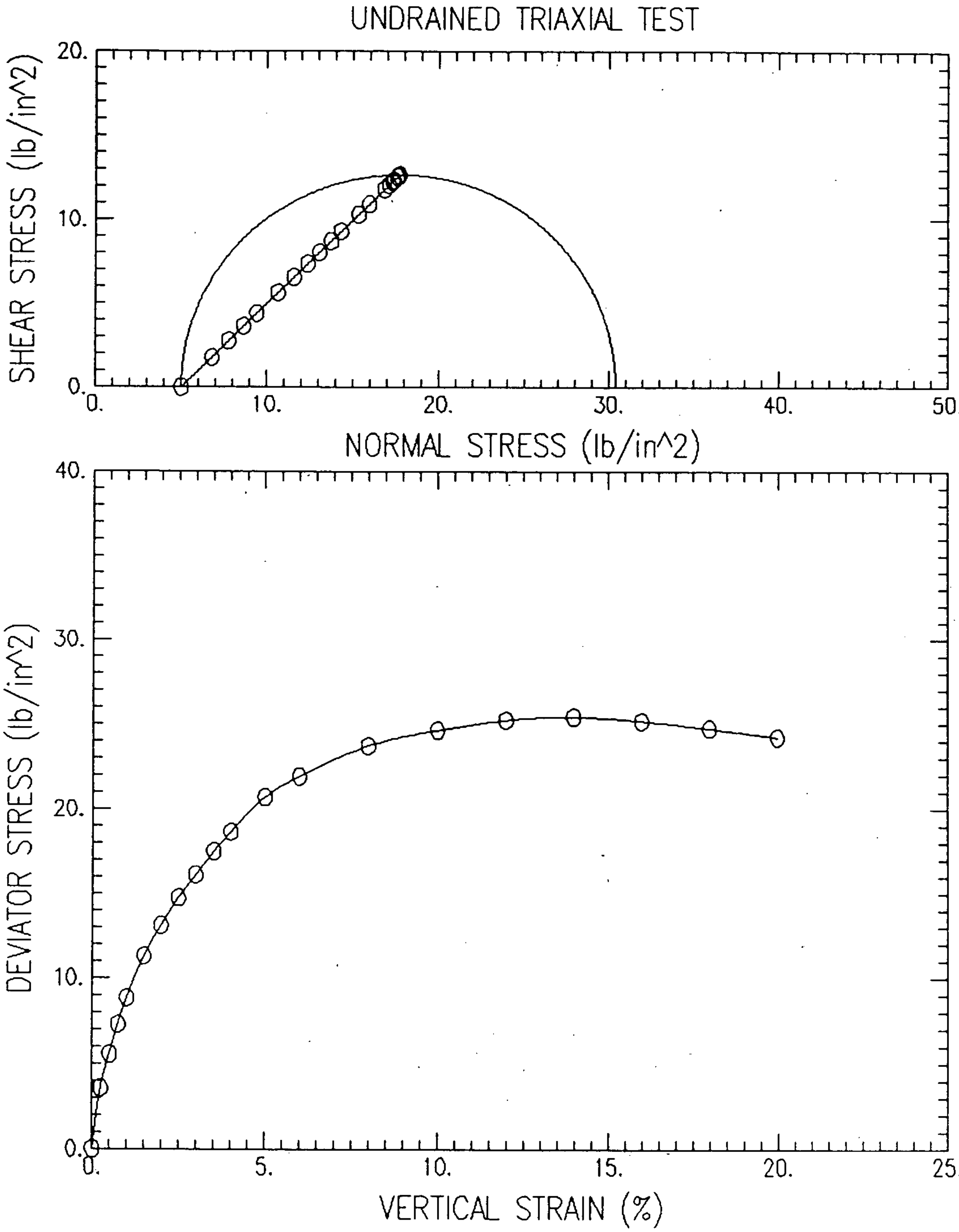
INITIAL WET DENSITY 123.15 pcf INITIAL DRY DENSITY 98.16 pcf

PROVING RING FACTOR 0.535 kgs/div

PROVING RING NO. 641 1.18 LBS/DIV.

| PROVING RING READING | AXIAL LOAD KGS. | VERT. COMP. INCH | % $\epsilon$ | 1- $\epsilon$ | | $\sigma_d$ KG/CM$^2$ |
|---|---|---|---|---|---|---|
| 0 | 0.00 | 0.000 | 0.00 | 1.0000 | | 0.00 |
| 6.5 | | 0.010 | 0.25 | | | |
| 9.5 | | 0.020 | 0.50 | | | |
| 12.5 | | 0.030 | 0.75 | | | |
| 16 | | 0.040 | 1.00 | | | |
| 21.5 | | 0.060 | 1.50 | | | |
| 26.5 | | 0.080 | 2.00 | | | |
| 31.5 | | 0.100 | 2.50 | | | |
| 35 | | 0.120 | 3.00 | | | |
| 39 | | 0.141 | 3.50 | | | |
| 42.5 | | 0.161 | 4.00 | | | |
| 48.5 | | 0.20 | 5.00 | | | |
| 54 | | 0.24 | 6.00 | | | |
| 62 | | 0.321 | 8.00 | | | |
| 70 | | [illegible] | 10.00 | | | |
| 73 | | [illegible] | 12.00 | | | |
| 69.5 | | [illegible] | 14.00 | | | |
| 67 | | [illegible] | 16.00 | | | |
| 66.5 | | [illegible] | 18.00 | | | |
| 66 | | [illegible] | 20.00 | | | |

Woodward-Clyde Consultants




| | | | | |
|---|---|---|---|---|
| Project Name : LEVINE-FRICKE LRTC #1530 | | | | Location : |
| Boring No: | Sample No | Depth | Test No | Filename |
| LC2-5 | LC2-5/18.5 | | LC2-5/18.5 | LC25185 |

# UNDRAINED TRIAXIAL COMPRESSION TEST

Project : LEVINE-FRICKE LRTC #1530
Project No. : 1618A
Boring No. : LC2-5
Sample No. : LC2-5/18.5
Soil Description : BROWNISH GRAY SILTY CLAY

Location :
Test No. : LC2-5/18.5
Test Date : 2/9/90
Depth :

Tested by : C. WASON
Checked by : S. CAPPS

Height : 4.020 (in)
Area : 2.96 (in^2)
Volume : 11.88 (in^3)

Piston Diameter : 0.000 (in)
Piston Friction : 0.00 (lb)
Piston Weight : 0.00 (gm)

Filter Correction : 0.00 (lb/in^2)
Membrane Correction : 0.00 (lb/in)
Area Correction : Parabolic

| | CHANGE IN LENGTH (in) | VERTICAL STRAIN (%) | CORR. AREA (in^2) | PORE PRESSURE (lb/in^2) | DEV. LOAD (lb) | CORR. DEV. LOAD (lb) | DEV. STRESS (lb/in^2) | TOTAL VERTICAL STRESS (lb/in^2) | EFFECTIVE VERTICAL STRESS (lb/in^2) |
|---|---|---|---|---|---|---|---|---|---|
| 1) | 0.000 | 0.00 | 2.96 | 0.00 | 0.00 | 0.00 | 0.00 | 5.00 | 5.00 |
| 2) | 0.010 | 0.25 | 2.97 | 0.00 | 10.62 | 10.62 | 3.58 | 8.58 | 8.58 |
| 3) | 0.020 | 0.50 | 2.98 | 0.00 | 16.52 | 16.52 | 5.54 | 10.54 | 10.54 |
| 4) | 0.030 | 0.75 | 2.99 | 0.00 | 21.83 | 21.83 | 7.29 | 12.29 | 12.29 |
| 5) | 0.040 | 1.00 | 3.01 | 0.00 | 26.55 | 26.55 | 8.83 | 13.83 | 13.83 |
| 6) | 0.060 | 1.49 | 3.03 | 0.00 | 34.22 | 34.22 | 11.29 | 16.29 | 16.29 |
| 7) | 0.080 | 1.99 | 3.06 | 0.00 | 40.12 | 40.12 | 13.12 | 18.12 | 18.12 |
| 8) | 0.100 | 2.49 | 3.08 | 0.00 | 45.43 | 45.43 | 14.73 | 19.73 | 19.73 |
| 9) | 0.120 | 2.99 | 3.11 | 0.00 | 50.15 | 50.15 | 16.12 | 21.12 | 21.12 |
| 10) | 0.141 | 3.51 | 3.14 | 0.00 | 54.87 | 54.87 | 17.48 | 22.48 | 22.48 |
| 11) | 0.161 | 4.00 | 3.17 | 0.00 | 59.00 | 59.00 | 18.63 | 23.63 | 23.63 |
| 12) | 0.201 | 5.00 | 3.22 | 0.00 | 66.67 | 66.67 | 20.67 | 25.67 | 25.67 |
| 13) | 0.241 | 6.00 | 3.28 | 0.00 | 71.98 | 71.98 | 21.92 | 26.92 | 26.92 |
| 14) | 0.321 | 7.99 | 3.41 | 0.00 | 80.83 | 80.83 | 23.71 | 28.71 | 28.71 |
| 15) | 0.402 | 10.00 | 3.55 | 0.00 | 87.32 | 87.32 | 24.62 | 29.62 | 29.62 |
| 16) | 0.482 | 11.99 | 3.69 | 0.00 | 93.22 | 93.22 | 25.23 | 30.23 | 30.23 |
| 17) | 0.562 | 13.98 | 3.85 | 0.00 | 97.94 | 97.94 | 25.41 | 30.41 | 30.41 |
| 18) | 0.643 | 16.00 | 4.03 | 0.00 | 101.48 | 101.48 | 25.18 | 30.18 | 30.18 |
| 19) | 0.723 | 17.99 | 4.22 | 0.00 | 104.43 | 104.43 | 24.74 | 29.74 | 29.74 |
| 20) | 0.803 | 19.98 | 4.43 | 0.00 | 107.38 | 107.38 | 24.23 | 29.23 | 29.23 |

UNDRAINED TRIAXIAL COMPRESSION TEST

Project : LEVINE-FRICKE LRTC #1530 Location :
Project No. : 1618A Test No. : LC2-5/18.5
Boring No. : LC2-5 Test Date : 2/9/90 Tested by : C. WASON
Sample No. : LC2-5/18.5 Depth : Checked by : S. CAPPS
Soil Description : BROWNISH GRAY SILTY CLAY

| | WATER CONTENT | | |
|---|---|---|---|
| | BEFORE TEST | AFTER TEST | TRIMMINGS |
| CONTAINER NO. | | | |
| WT CONTAINER + WET SOIL (gm) | 380.08 | 0.00 | 0.00 |
| WT CONTAINER + DRY SOIL (gm) | 295.20 | 0.00 | 0.00 |
| WT WATER (gm) | 84.88 | 0.00 | 0.00 |
| WT CONTAINER (gm) | 0.00 | 0.00 | 0.00 |
| WT DRY SOIL (gm) | 295.20 | 0.00 | 0.00 |
| WATER CONTENT (%) | 28.75 | 0.00 | 0.00 |

| | INITIAL | AT CONSOLIDATION |
|---|---|---|
| WATER CONTENT (%) | 28.75 | 28.75 |
| VOID RATIO | 0.80 | 0.80 |
| WET DENSITY (lb/ft^3) | 121.85 | 121.85 |
| DRY DENSITY (lb/ft^3) | 94.64 | 94.64 |
| DEGREE OF SATURATION (%) | 98.12 | 98.12 |

Maximum Shear Stress = 12.71 (lb/in^2) at a Vertical Strain of 13.98 %

File# LC2-5185

# U U - TRIAXIAL TEST DATA

PROJECT NAME LEVINE - FRICKE # 1530 PROJECT NO. 16148A

SAMPLE NO. LC2-5/18.5 DATE 2/9/90

DESCRIPTION Gray-slightly brn - si-clay

TESTED BY C. Wasm REDUCED BY C. Wasm CHECKED BY S. Capps

DIAM$_o$ 1.94 cm. AREA$_o$ 19.07 cm.$^2$ 2.956 in$^2$ HEIGHT$_o$ 4.02" = 10.2 cm.

WET WT. BEFORE TEST 380.08 gms. WATER CONT. B.T. 28.75 %

DRY WT. AFTER TEST 295.2 gms. $\sigma_{3c}$ 5.0 psi = 0.352 kgs/cm$^2$

INITIAL WET DENSITY 121.93 pcf INITIAL DRY DENSITY 94.70 pcf

PROVING RING FACTOR 0.535 kgs/div

PROVING RING NO. 641 1.18 lbs/div

| PROVING RING READING | AXIAL LOAD KGS. | VERT. COMP. INCH | % $\epsilon$ | 1-$\epsilon$ | $\sigma_d$ | $\sigma_d$ KG/CM$^2$ |
|---|---|---|---|---|---|---|
| 0 | 0.00 | 0.000 | 0.00 | 1.0000 | | 0.00 |
| 9 | | 0.010 | 0.25 | | | |
| 14 | | 0.020 | 0.50 | | | |
| 18.5 | | 0.030 | 0.75 | | | |
| 22.5 | | 0.040 | 1.00 | | | |
| 27 | | 0.060 | 1.50 | | | |
| 34 | | 0.080 | 2.00 | | | |
| 38.5 | | 0.100 | 2.50 | | | |
| 42.5 | | 0.120 | 3.00 | | | |
| 46.5 | | 0.141 | 3.50 | | | |
| 50 | | 0.161 | 4.00 | | | |
| 56.5 | | 0.201 | 5.00 | | | |
| 61 | | 0.241 | 6.00 | | | |
| 68.5 | | 0.321 | 8.00 | | | |
| 74 | | 0.402 | 10.00 | | | |
| 79 | | 0.482 | 12.00 | | | |
| 83 | | 0.562 | 14.00 | | | |
| 86 | | 0.643 | 16.00 | | | |
| 88.5 | | 0.723 | 18.00 | | | |
| 91 | | 0.803 | 20.00 | | | |

# UNCONFINED COMPRESSION-MOISTURE-DENSITY TEST

Proj. Name L E FRICKE LRTC 1530 Proj. No. 16148A Date 2/17/90

Tested by S. Capps | Reduced by S. Capps | Checked by [illegible] | Strain Rate 1 %/min

**Proving Ring Constant**

| Mach. No. | S/N. | Constant lb/div. | STORE |
|---|---|---|---|
| 1 (B') | 644 | 1.130 | 10 |
| 2 (C') | 643 | 0.928 | 11 |
| 3 (C') | | | 12 |

| Sample No. | A Diameter in. | B Height cm. | C Total Wet Weight gm. | D Oven Dry Weight gm. | E Wet Weight if less than total gm. | Axial Deformation A' Initial | Axial Deformation R/S Final | Proving Ring Reading div. | Sample Description |
|---|---|---|---|---|---|---|---|---|---|
| C3 3/11 | 1.94 | 10.9 | 400.3 | 306.9 | — | 0.000 | .170 | B' C' D' 24 | BRN FINE SANDY SILTY CLAY-CL TO CLAYEY SAND SC |
| LC4 5/16 | " | 12.0 | 448.4 | 353.3 | — | 0.000 | .305 | B' C' D' 100 | GRAY SILTY CLAY CL-CH |
| LC4 7/26 | " | 12.9 | 479.7 | 374.3 | — | 0.000 | .400 | B' C' D' 115 | GREENISH GRAY CLAY CL-CH |
| LC7 3/16 | " | 7.3 | 351.7 | 282.2 | — | 0.000 | .240 | B' C' D' 38 | GREENISH GRAY SILTY CLAY CL |
| LC7 4/30 | " | 11.4 | 422.2 | 337.2 | — | 0.000 | .365 | B' C' D' 98 | GRAY BROWN SILTY CLAY CL |

**C3 3/11**

| | |
|---|---|
| Moisture, percent | — |
| Wet Density, pcf | |
| Dry Density, pcf | |
| H/D Ratio | 92.13 |
| Unconf. Comp., U, psf | 2.21 |
| Strain, % at U | 1042.4 |
| | 4.0 |

**LC4 5/16**

| | |
|---|---|
| Moisture, percent | 26.92 |
| Wet Density, pcf | 122.27 |
| Dry Density, pcf | 96.34 |
| H/D Ratio | 2.44 |
| Unconf. Comp., U, psf | 4230.5 |
| Strain, % at U | 6.5 |

**LC4 7/26**

| | |
|---|---|
| Moisture, percent | 28.16 |
| Wet Density, pcf | 121.68 |
| Dry Density, pcf | 94.94 |
| H/D Ratio | 2.62 |
| Unconf. Comp., U, psf | 4791.2 |
| Strain, % at U | 7.9 |

**LC7 3/16**

| | |
|---|---|
| Moisture, percent | 24.63 |
| Wet Density, pcf | 123.74 |
| Dry Density, pcf | 99.29 |
| H/D Ratio | 1.89 |
| Unconf. Comp., U, psf | 1605.9 |
| Strain, % at U | 6.6 |

**LC7 4/30**

| | |
|---|---|
| Moisture, percent | 25.21 |
| Wet Density, pcf | 121.18 |
| Dry Density, pcf | [illegible] |
| H/D Ratio | |
| Unconf. Comp., U, psf | — |
| Strain, % at U | |

**Woodward-Clyde Consultants**

UNCONFINED COMPRESSION ' 'STURE-DENSITY TEST



Proj. Name L # 1530 Proj. No. 16148 2/7/90

Tested by S. Capps | Reduced by S Capps | Checked by | Strain Rate 1 %/min

| Sample No. | A Diameter in. | B Height cm. | C Total Wet Weight gm. | D Oven Dry Weight gm. | E Wet Weight if less than total gm. | Axial Deformation A' Initial | Axial Deformation R/S Final | Proving Ring Reading div. | Sample Description |
|---|---|---|---|---|---|---|---|---|---|
| C7 1/26 | 1.94 | 9.0 | 343.5 | 271.4 | — | 0.000 | .354 | B' C' D' 81 | BRN SILTY CLAY CL |
| | | | | | | 0.000 | | B' C' D' | |
| | | | | | | 0.000 | | B' C' D' | |
| | | | | | | 0.000 | | B' C' D' | |
| | | | | | | 0.000 | | B' C' D' | |

Proving Ring Constant

| Mach. No. | S/N. | Constant lb/div. | STORE |
|---|---|---|---|
| 1 (B') | 644 | 1.130 | 10 |
| 2 (C') | 643 | 0.928 | 11 |
| 3 (C') | | | 12 |

| | |
|---|---|
| Moisture, percent | |
| Wet Density, pcf | [illegible] |
| Dry Density, pcf | 98.67 |
| H/D Ratio | 1.83 |
| Unconf. Comp., U, psf | 3297.2 |
| Strain, % at U | 10.0 |

Moisture, percent
Wet Density, pcf
Dry Density, pcf
H/D Ratio
Unconf. Comp., U, psf
Strain, % at U

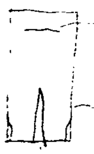
Moisture, percent
Wet Density, pcf
Dry Density, pcf
H/D Ratio
Unconf. Comp., U, psf
Strain, % at U

Moisture, percent
Wet Density, pcf
Dry Density, pcf
H/D Ratio
Unconf. Comp., U, psf
Strain, % at U

Moisture, percent
Wet Density, pcf
Dry Density, pcf
H/D Ratio
Unconf. Comp., U, psf
Strain, % at U

Th 2/8/90

LC3-3/11



1 horizontal crack all the way thru (but not visible on outside all way thru)

clay on outside
peeled up ½" at bottom
exposing sand

2 vertical cracks going ½ way up

Sand within all cracks; not in entire sample though when I broke it open

LC4-5/16

no sand

LC4-7/26

4 major vertical cracks

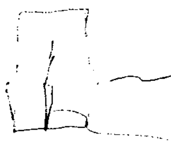
Bulge in specimen sides like bottom of specimen was pushed up & over top

When broken open, sample has patches of white, hard & dry CaCO₃ ?

p. 13

Th 2/8/91

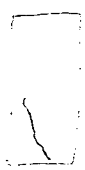
LC7-3/16



When broken, fine sandy layer seen ~10° above the goulet at bulge

a couple vertical cracks; penetrating up to 3/8" into specimen

LC7-4/20



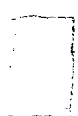
No bulge

Only 1 pronounced crack, penetrating 1/8" into specimen

& opposite side has several v. light vertical cracks

No sand or $CaCO_3$ apparent when break specimen open

LC7-5/36



One light crack; penetrating only 1/16"

No sand apparent when break specimen open,

but rust staining & trace white $CaCO_3$ nodules/ patches

Woodward-Clyde Consultants

GRAIN SIZE DISTRIBUTION CURVES

PROJECT NAME LEVINE-FRICKE - LRTC # PROJECT NO. 16148A

TESTED BY CW/SC 2/16/90 PLOTTED BY S Coppo 2/21/90 REVIEWED BY C. [illegible] 2/21/90

SAMPLE NO. LC2-4 DEPTH 13 FEET U.S.C.S. ML-CL

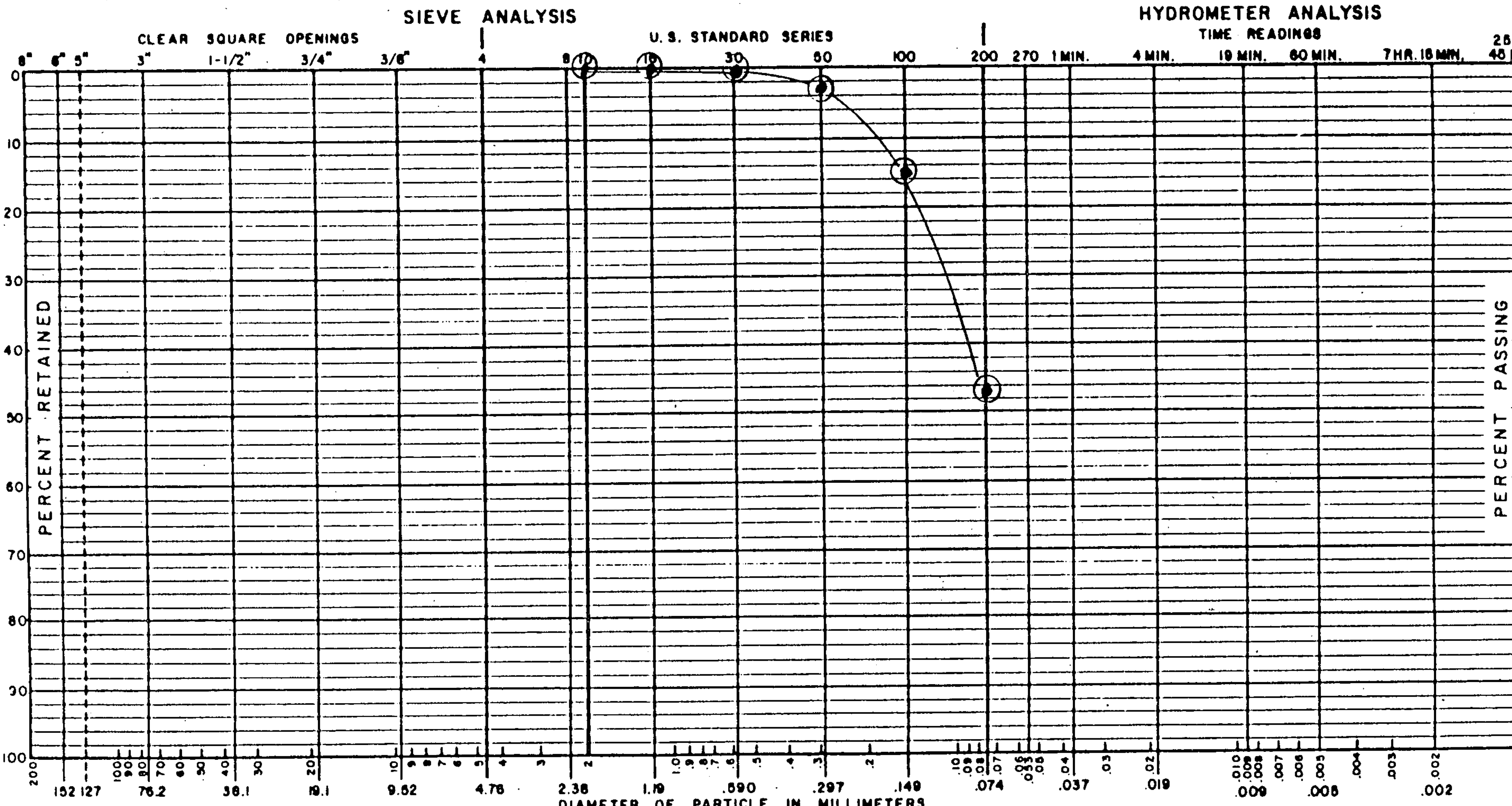
LIQUID LIMIT — $D_{10\%}$= $C_u$=

PLASTICITY INDEX — $D_{30\%}$= $C_c$=

$D_{60\%}$=

WELL GRADED

| GRAVEL | SAND |
|---|---|
| $C_u > 4$ | $C_u > 6$ |
| $C_c \geq 1 \leq 3$ | $C_c \geq 1 \leq 3$ |




| COBBLES | GRAVEL | | SAND | | | CLAY (PLASTIC) TO SILT (NON-PLASTIC) |
|---|---|---|---|---|---|---|
| | COARSE | FINE | COARSE | MEDIUM | FINE | |

# SIEVE ANALYSIS

PROJECT NAME LEVINE - FRICKE #1530 PROJECT NO. 16148A

SAMPLE NO. LC2-4/13 DATE 2/21/90

DESCRIPTION Greenish gray - slightly brn - fine sandy clay ML-CL

TESTED BY CW/SC REDUCED BY S. Capps CHECKED BY [illegible]

## COARSE SIEVE ANALYSIS

WT. AIR DRY SOIL RETD. #10 ________ GMS. WT. AIR DRY SOIL PASSING #10 ________ GMS.

WT. OVEN DRY SOIL RETD. #10 ________ GMS. HYGROSCOPIC WATER CONTENT ________ %

WT. OVEN DRY SOIL RETD. ON #10 AFTER WASHING ________ GMS. WT. OVEN DRY SOIL PASSING #10 ________ GMS.

TOTAL WT. DRY SOIL PASSING #10 ________ GMS.

TOTAL WEIGHT OF DRY SOIL USED IN TEST ________ GMS. ($W_s$)

| SIEVE SIZE | CUMULATIVE WT. RETAINED ON SIEVE | % PASSING | |
|---|---|---|---|
| 2" | | | |
| 1½" | | | |
| 1" | | | |
| 3/4" | | | |
| 1/2" | | | |
| 3/8" | | | |

## FINE SIEVE ANALYSIS

WT. OF AIR DRY SAMPLE USED IN TEST ________ GMS. WT. OF OVEN DRY SAMPLE ________ GMS. ($W_s$)

| | | | HYDROMETER MATERIAL-MULTIPLY BY % PASSING #10 SIEVE |
|---|---|---|---|
| NO. 4 | 0.00 | 100.00 | |
| NO. 10 | 0.06 | 99.98 | |
| NO. 16 | 0.30 | 99.92 | |
| NO. 30 | 1.58 | 99.57 | |
| NO. 50 | 11.12 | 96.96 | |
| NO. 100 | 53.72 | 85.25 | |
| NO. 200 | 170.63 | 53.32 | |
| PAN | 170.99 | BREAKDOWN | ________ |

MOIST WEIGHT + TARE 690.3 GMS. WASHED DRY WEIGHT + TARE ________ GMS.

OVEN DRY WEIGHT + TARE 587.20 GMS. TARE ________ GMS.

TARE 221.62 GMS. WASHED DRY WEIGHT ________ GMS.

MOISTURE CONTENT 38.30 % OVEN DRY WEIGHT ($W_s$) 365.58 GMS.

COMMENTS: ________

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